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An exploration of the perceptions domestic groundwater users hold in relation to Perth's groundwater resources

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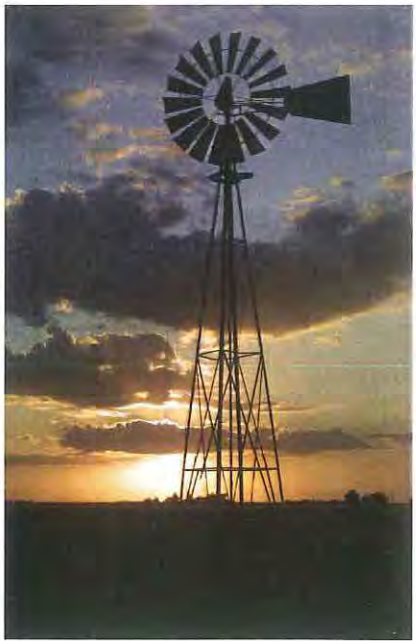
AN EXPLORATION OF THE PERCEPTIONS DOMESTIC GROUNDWATER USERS HOLD IN RELATION TO PERTH'S GROUNDWATER RESOURCES



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FOREWORD

The work that has gone into this project over the past year has been both enjoyable and at times extremely challenging. Based in the discipline of qualitative social research, it is a far cry from the quantitative, ecologically based, research I had been used to. Learning the methodologies of qualitative research took the better half of the year – and having to conduct interviews, well that took the better part of my confidence.

Along this journey I have developed an increased sense of the value behind qualitative research –as they say, behind every number there's a value. I believe qualitative research in the natural sciences has a great deal to offer policy makers and resource managers, both in shaping future directions for research and providing rich insights into the range of values and perceptions people hold, which can assist in developing the approaches taken to manage our natural resources for the long-term good.

I am grateful for the opportunity to undertake such a project, and thank the School of Natural Sciences for their support throughout my entire journey as a university student.

ABSTRACT

Australia's water resources over the next few decades, and most likely beyond, will be under increasing pressures as populations enlarge and as the amount of water per person becomes more limited from a decline in rainfall across much of the continent. Perth is considered lucky among most Australian cities when it comes to water resources, in that we have an extensive groundwater network that is readily accessible both for both private (wells and bores) and public (scheme water) supplies. However, this resource has also seen substantial declines over the last few decades resulting from declining rainfall and increased use.

Although domestic users individually may have minimal impact on the groundwater, their cumulative impact may be far greater. At some stage we will need to understand the variety and complexities among this user group if we are going to manage water effectively, without having to raise the price beyond what an average family can afford –it is water after all, it can not be denied from those simply too poor. Understanding and trust needs to be built among a community of users if they are going to work together with resource managers through an understanding of the nature of the resource the need for restrictions and regulations. However, before we can develop such understandings we first need to develop an awareness of the perceptions that exist within this group, followed by understanding as to how it may influence their behaviour.

To obtain a sample of such perceptions to groundwater resources, a qualitative study was designed to gain an insight into the broad range of perceptions that might exist within this community. An in-depth interview was developed and undertaken among a small community of users. The data obtained were analysed and coded according to a set of themes and issues that were present throughout the interviews. From here some discussions were presented about the potential meaning of such data and the implications it may have for management or behaviour modification campaigns (i.e. promoting water conservation behaviours etc.).

A variety of commonly held perceptions existed for a number of themes. The majority of participants were aware of a decline in Perth's groundwater resources, with most attributing this to either overuse, particularly by irrigators, and or to a decline in rainfall. On the topic of property rights in water, most did not believe that individuals had

ownership rights over groundwater, but rather it was a commonly owned resource, with many suggesting that government had the ultimate control in ensuring the resource is allocated equitably and sustainably. On the topic of recommendations for policy makers, many had suggested the ways in which we need to start obtaining new water sources, as opposed to the better management of our existing water supplies. However, many also suggested the education of groundwater users on such things as restrictions and why they have been put in place.

Some of the main findings of most concern to resource managers are those relating to equity in regards to fees being applied to groundwater use, potential misconceptions, the expressed need for better education of groundwater users, the nature in which people appear more in favour of deflecting the issue than changing management and use and the lack of awareness as to who manages the groundwater and what their role is.

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I send sincere thanks to those residents of Morley who spared their time to have me interview them – to all, thank you for welcoming me in to your homes on those rainy days. Without people in our communities willing to offer a little time for a research students project, such projects would not be possible and in their place only a gap would exist.

Lastly, but certainly not least, I would like to thank my family for all their support and encouragement and I thank my friends for their understanding. I especially would like to thank my mum for spending those long rainy days sitting in my car while I did interviews, my dad for his support and editing advice, and my dear partner who, amazingly, has put up with me the whole way through – Thank you!

For those of you who think qualitative research is easy, I challenge you to undertake such a project, and for those of you who do this for a living, I admire the abilities you must have to manage the rich data gathered from such research. When one is faced with almost 100 pages of raw transcripts to code and divide, (and that's only from 10 interviews) it can be quite overwhelming.

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Cover Image sourced from the Research Institute for Sustainable Energy (RISE) Retrieved 25th October, 2008, from www.rise.org.au/.../Windpumping/index.html

CHAPTER 1:
INTRODUCTION

1.1 FACING WATER SCARCITY.

Fresh water is a basic necessity of life and has an important place both in environmental and societal processes (Gleick, 1993). Water is becoming one of the largest, and certainly the most universal, of problems facing human populations (Winpenny, 1994). On a global scale, 97% of all water is not suitable for drinking or irrigation, being that it exists as salt water - the remaining 3% is fresh water. Of this 1.7% is available as groundwater, with only 0.76% being fresh and usable (i.e. not stored as soil moisture) (Gleick, 1993).

Because the total amount of fresh water on earth is finite, individuals in growing populations will be continuously pressured to reduce their use as the amount available per person will decline (Gleick, 1993). Add to this the uncertainties surrounding the world's water supplies in the future if climate change predictions are correct, most suggesting higher temperatures and lowering rainfall in many areas across the globe.

Australia is one such country facing water scarcity issues across most of its population centers. Australia has long been widely recognised as the driest inhabited continent on Earth, not only because rainfall is low, but also the actual amount of rainfall that contributes to stream flow after evaporation and transpiration is also low (Pigram, 2007). With increasing urbanisation around Australia, increasing pressures are being placed on water resources, with declining rainfall patterns only making matters worse (Pigram, 2007). Some argue that water, already a scarce resource, is being treated as though it were plentiful and free, with the market being insufficiently used as a means to control demand – as is the case with most scarce resources (Winpenny, 1994).

Extensive water use restrictions do exist in most Australian Capital Cities, however they are considerably more stringent than those in Perth (Pigram, 2007; Playford, 2005). Perth is unique among Australian capital cities, in that there is relatively easy access to groundwater resources. Perth differs from Sydney, Melbourne, Brisbane, and Adelaide, who, being more dependent on surface water supplies, are more vulnerable to short - or long-term declines in rainfall (Playford, 2005).

Extensive groundwater resources exist throughout major sedimentary basins (including the Great Artesian Basin) that extend under 60% of the continent, making groundwater an important water resource in the inland and arid zones (Pigram, 2007). Groundwater is contained in the pore spaces between the materials (sands, gravels, limestone, fracture granite etc.) that comprise the geological strata in which the groundwater exists – known as an aquifer (Goesch, Hone & Gooday, 2007). Groundwater is discharged naturally into the environment, such as through rivers and springs and into the ocean, groundwater can also be abstracted for human use (irrigation, domestic supplies, etc.) by sinking wells or bores.

There is no doubt that Australia is experiencing a time of climatic uncertainty and there is little consensus in predictions on the future climate of the country (Playford, 2005). We do know that a decline in rainfall has been experienced across the South West over the past 3 decades, which has resulted in about 50% less runoff into dams in the Darling Range (Playford, 2005). This decline in rainfall and subsequent decline in water resources has been resulting in authorities making dire predictions regarding the future of Perth water supplies and agriculture in the South West and has become a growing concern to Government and the public (Playford, 2005).

1.1.2 Groundwater in Perth - Western Australia.

In Western Australia (WA), Perth is the only large urban center, with a population estimated at 1.5million people, double that of 30 years ago, accounting for 74% of the total WA population (Environmental Protection Authority, 2007a). The metropolitan area has also doubled in size during that time, estimated at 63 000ha as of 2002 (Environmental Protection Authority (EPA), 2007a), an area equivalent to many large European cities (Appleyard *et al.,* 1999). Perth is also very much a garden city with the majority of the population living on blocks of $500m^2$ – $1000m^2$ with gardening a popular past time as most blocks are adorned with large gardens of exotic lawns and plants (Appleyard *et al.,* 1999).

Perth is situated over large groundwater resources, known as the Jandakot and Gnangara mounds (see Figure 7) so it's not surprising that the dominant source of water in Perth is groundwater, supplying 60% of the metropolitan scheme water supply (Playford, 2005).

The rest comes from dams, from which the Water Corporation meets about 40% of Perth's domestic water needs (Playford, 2005). Also drawing on the groundwater resource are the private bores of industrial and domestic users, using an estimated 200 GL and 100 GL per annum respectively (Australian Academy of Technological Sciences and Engineering, 2002).

The Gnangara Mound, from where a larger majority of the water supply is abstracted, covers an area of approximately 2,200 square kilometres, extending from the Swan River to the south, to Gingin Brook in the north and inland to Ellen Brook and the Darling Fault (Department of Water, nd). The aquifers of the Gnangara Groundwater Areas represent one of the largest sources of potable water in the south west of Western Australia (DoW, nd).

Since the development of the shallow groundwater resources of the Gnangara Mound in the 1960's, the urban area has encroached on land previously undeveloped, which overlie groundwater recharge areas, and as well as an increase in use, have affected groundwater recharge rates (Appleyard *et al.,* 1999). Over the last few decades the water table (Figure 1 Appendix A) has dropped significantly in some parts of the groundwater area and some groundwater dependent ecosystems (e.g., wetlands, Banksia woodlands, etc) have shown severe signs of stress (Department of Environment, 2005). This coincides with the two main stressors on the system: the increases in private and public abstraction rates and the general trend of declining annual rainfall (Figure 2 Appendix A) across the south west of Western Australia (PMSEIC IWG, 2007).

In 2006, bore water was used by one-quarter of Perth households (26%), a proportion that has risen from 24% in 2003 and 22% in 1992 (ABS, 2007). In 2006 the number of households that use bore water was 150,900, an increase from 99,600 in 1992 (ABS, 2007). In some suburbs of Perth (including Morley, Applecross, Bullcreek and Rockingham), more than 75% of houses have garden bores (EPA, 2007b).

Currently under the *Waterwise Rebate Scheme*, an initiative of the State Government run through the Department of Water, cash rebates of $300 or 50% towards the installation costs of a garden bore (whichever is the lesser amount) can be received (providing the bore is not too near the ocean, rivers or wetlands) (DOW, 2007). This was an initiative originally developed through the Water Corporation as a means to help

reduce householder's use of the potable water supply grid for garden purposes. However, some have suggested that the Water Corporation's insistence that bore water is a viable, sustainable alternative to scheme water supplies may have the effect of undermining the conservation attitude they are trying to promote (Troy, 2007). With the increase in the installations of garden bores throughout the metropolitan area concerns about bore water have been raised recently in relation to its possible impact on ground water levels (EPA, 2007a).

As it would appear, groundwater, rather than dams, looks to be the major source of any increase in supplies (Playford, 2005). Water demand for Perth and adjoining areas is expected to double in less than 50 years, so that long-term planning by Government to meet the water needs for this period and beyond is essential (Playford, 2005).

As groundwater will increasingly become an important water resource for Perth's water supplies, it is likely that in order to get support and understanding of management objectives (restrictions, etc.), it is necessary that the characteristics of the groundwater users be explored. As Gilg and Barr (2006) have stated, by identifying the characteristics of water users, policy makers can more accurately target initiatives for water conservation, so thorough explorations of the different water users is an essential aspect for more effective water management in the future.

In a sense water is the ultimate common property, being that it does not stay in one location (flow and evaporation, etc.) and circulates on a global scale. As common property resources become scarce, there is a theory that resource harvesters will inevitably act in self-interest and take what they can, rather than acting in the long-term interest and considering the sustainability of such actions among the community (Gifford, 2002). Such situations are known in the literature as social or commons dilemmas and they are taking on greater importance as common resources diminish and need careful management by all users (Thompson, 1991).

This project was designed to qualitatively explore domestic groundwater users perceptions to a wide range of aspects in relation to their perception of the nature of groundwater around Perth as well as their perceptions of management and use issues and their recommendations. The exploration of the perceptions held by domestic groundwater users was important for this study as it has been widely supported that the

way in which the environment is perceived is influential on ones behaviour within that environment (Gregory and Wellman, 2001). It is hoped that this information will provide an insight for policy makers on the levels of awareness and knowledge people may have in relation to groundwater resources around Perth so that possible areas for improvement can be further identified and explored.

Before exploring these perceptions a number of issues first need to be introduced, those including property rights and how they apply to groundwater, the purpose of studying environmental perceptions and the role it can play in natural resource management and the nature of qualitative research. These issues will be addressed through the following literature review.

1.2 LITERATURE REVIEW.

1.2.1 PROPERTY REGIMES: BACKGROUND.

Property rights are a fundamental component of a society's institutional system, arising from, and conditioned by, rules in constitutional documents, statute law and the doctrines and precedence of Common law (Conner & Dovers, 2002). Property rights were developed to assist in building the incentive structures that help to reduce the uncertainty about the behaviour of others and make higher levels of coordination and social organisation possible (Conner & Dovers, 2002).

There are four main property regimes as recognized by the literature; those being private property, state property, common property, and open access (or non property) (see Table 1 following).

Table 1: Overview of Characteristic of the Four Main Property Regime Types (adapted from Bromley & Cernea, 1989; Martin & Verbeek, 2002 & Conner & Dovers, 2002).

Property Regime	Characteristics
Private Property	Individual has right to undertake socially acceptable uses of resource; to exclude others from those uses; and to sell or rent the property to others
State Property	Resource rights held by government agencies who determine use/access rules to which individuals have a duty to observe; may grant free public access; and use force to enforce rules.
Common Property	Resource held by a community of users or management group; may self regulate appropriate uses and exclude others; and may still be defined by larger society or external power.
Open Access – Non Property	No defined group of users/owners; benefits free to anyone.

For the purposes of this literature review, private property regimes will not be examined at great depth as they are not applicable to groundwater resources in Western Australia (Newell, 1999). Those that are applicable, and will be discussed in this review, are State (SPR) and Common Property Regimes (CPR), with Open access regimes being included so as to highlight the differences between common pool resources and open access resources, two regimes that have long caused confusion.

There are marked differences between the structure and nature of the varying property regimes. In a state property regime, ownership and control over resource use rests in the hands of the state, with individuals and groups being able to make use of the resource, but only as decided by the state (Bromley & Cernea, 1989). National (or State) forests, National (or State) parks, military reservations, and groundwater for industry, agriculture and commercial use are considered as being part of state property regimes and require a licence from the State to abstract groundwater.

In relation to common property and open access resources, or "non-property" as Martin and Verbeek (2002, p.3) have termed it, there has long been confusion between the two. There is a belief that common property eventually results in the destruction of the resource (or property) because of the inability to control over-consumption by users (Martin & Verbeek, 2002). Garrett Hardin provides the exemplar:

> Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all (Hardin, 1968, p. 1244).

The frequently cited 'tragedy of the commons' and 'commons dilemmas', has been argued to essentially be about resource degradation because of *open* access regimes, not common property. Those who criticise the theory do so because they believe it ignores the socio-organisational arrangements able to overcome resource degradation and which make the common property regime viable (Bromley & Cernea, 1989).

Common property is, in essence, private property for the group, it is not the free-for-all of open access resources, as individuals have rights and obligations in situations in common property just as in private property situations (Bromley & Cernea, 1989). Common property regimes can be workable provided there are rules for determining the use of and access to the resource and also providing that these rules are enforceable and enforced (Watson, 2006).

According to the World Bank, common property regimes are structured ownership arrangements within which "management rules are developed, group size is known and enforced, incentives exist for co-owners to follow the accepted institutional arrangements, and sanctions work to insure compliance" (Bromley & Cernea, 1989, p. iii).

To assist in their clarification of common pool resources Conner and Dovers' (2002, p.121) used the following definition to help clarify what they meant when discussing common pool resources (cited from Dietz *et* al., 2002):

> A common pool resource is a valued natural or human made facility that is available to more than one person and subject to degradation as a result of overuse. Common pool resources are one for which exclusion from the resource is costly and one person's use subtracts from what is available to others.

As these definitions imply, and unlike open access regimes, common property regimes are potentially able to define a number of parameters within the resource user community, including the group themselves; the rules of agreement and means for maintaining compliance; the basis of rights over time and between generations; unit of

control (community board etc); and how sanctions are imposed and disputes settled (Martin & Verbeek, 2002). Table 2 below provides an overview of the property rights that exist in common pool resources.

In the realm of natural resource management, common property regimes can offer many potential benefits over private property, but only when interdependence between resource users is a fundamental part of the social structure and resource use (Martin & Verbeek, 2002). The disadvantages lie in the potential for high costs in maintaining compliance in use and access, to the exclusion of others, unless strong social self-sanctions exist (Martin & Verbeek, 2002).

Table 2: Property Rights in Common Pool Resources (Conner & Dovers, 2002, p. 122).

Access	The right to enter a defined physical area and enjoy non-subtractive benefits (eg. hike, canoe, etc.)
Withdrawal	The right to obtain the resource units or products of a resource (eg. catch fish, take water, etc.)
Management	The right to regulate internal use patterns and transform the resource by making improvements.
Exclusion	The right to determine who will have an access right, and how that right may be transferred.
Alienation	The right to sell or lease either or both of the above collective choice rights

Martin and Verbeek (2002) further consider a well functioning common property regime is distinguished by being:

- an efficient regime: one where there is a minimum (or absence) of disputes and limited effort to maintain compliance;
- a stable regime: one that has the capacity to cope with changes through adaptations, such as the arrival of new production techniques;
- a resilient regime: one with the capacity to accommodate shocks; and
- an equitable regime : one where there exists a shared perception of fairness with respect to inputs and outcomes.

To date, one of the more comprehensive lists of design principles for successful CPR's is that developed by Ostrom (1990, see page 99) based on characteristics of long

enduring CPR institutions of today. They included having clearly defined boundaries (in terms of the resource itself, who can use and when), a congruence between rules and local conditions, collective choice arrangements and conflict resolution mechanisms for resource users, monitoring of appropriate behaviour and graduated sanctions for offences, and appropriators having the right to develop rules and institutions free from challenges of external government bodies.

Marsden's (2002) five design principles, as shown below, helps create a more conceptual image of Ostroms design principles (see Figure 1 below) In meeting all these criterion and design principles it can be seen that compromise or conflict is often likely to arise, such as the common conflict between the need to keep access rights simple but defined for economic purposes (trade and returns) with the need to manage third party effects on top of which, also ensuring environmental sustainability within the ecosystem (Marsden, 2002).

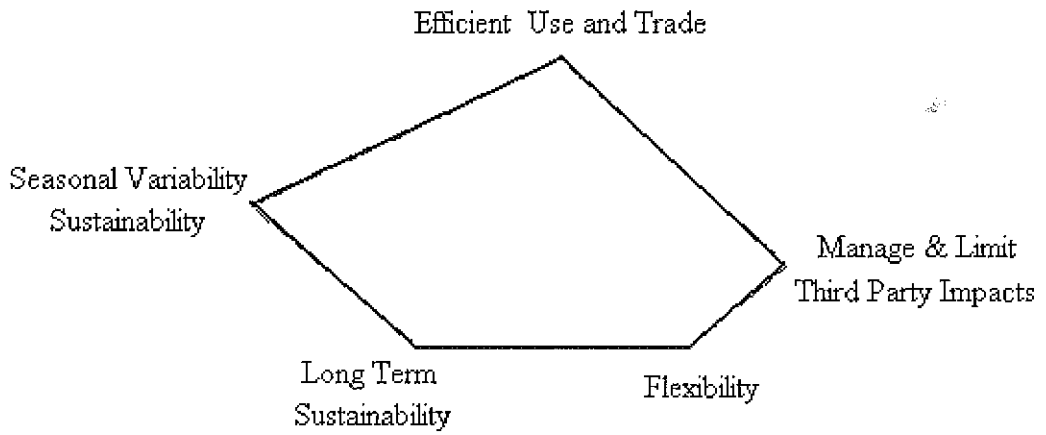

Figure 1: Design Criteria for Access Rights to a Common Pool Resource (from Marsden, 2002, p.48)

1.2.1.1 WATER AND PROPERTY RIGHTS IN AUSTRALIA.

In a dry continent like Australia, water resources management, policy, and law is one of the most important areas of natural resource management, considering water is one of the fundamental necessities for life and the environment (Tan, 2002), with the last few decades especially having seen major reforms in water legislation, caps on the growth of extractive water use in major systems, and the introduced planning mechanisms aimed to reduce over-use and the subsequent decline in ecosystem health (Marsden, 2002).

Up until 1896, the dominance of common law reinforced the notion that property rights extended to the groundwater below an individual's land, a mindset that can still be seen to explain some of the reasons why groundwater has been overexploited in many parts of the nation for so long (McKay, 2007). The approach of the common law to property in land is derived from the Latin maxim *"cuius est solum eius est usque ad coelum et ad inferos!"* basically meaning that whoever owns the surface of the land also "owns the depth below it to the center of the earth and the skies above it to the heavens" (Water and Rivers Commission, 1998, p. 5). This approach has been both modified at common law by the courts and altered by legislation so as to remove the assumption of ownership a land owner has over the groundwater beneath their land (WRC, 1998).

According to the Water and Rivers Commission (1998) it is difficult to accommodate water within the traditional common law notions of property because of its mobility: it does not remain attached to the land but is distributed by natural or artificial means and autonomously leaves its original site. Both common law and civil law now refuse to acknowledge property in the case of groundwater, as ownership of property requires an exact delimitation as to the physical characteristics of the resource or property (boundaries etc.) (WRC, 1998).

The initial common law rules to water were gradually replaced by a licensing and allocation system for both surface and groundwater with the Crown (that being State Government) being given the rights to the use, flow and control the groundwater (McKay, 2007). The rights to water are not owned by the State but rather vested for the purposes of management where rights to access and use the resource are granted by the State to individual users (Marsden, 2002; Watson 2006). The Water and Rivers Commission (1998) believes such a regime for the control and management of water as

a public resource incapable of ownership is logical, wherein individuals may obtain rights to use the resource but not equating to any degree of ownership of the water - the licence itself may be regarded as property if it accords exclusive rights on the licence holder and can be transferred but the water to which the licence entails is not. Rights to use water will depend upon access to the resource, this includes physical access arising from the proximity of water to the owned land (WRC, 1998). The rights of the Crown are however not exclusive as they provide for the recognition of common law rights for groundwater use for domestic and stock watering uses in most Australian Jurisdictions (Newell, 1999; McKay, 2007).

In Western Australia, the right to use, flow and control over all groundwater is vested in the Department of Water (formerly Department of Environment) by the *Rights in Water and Irrigation Act 1914* (RIWI) which provides licensing requirements for the use of groundwater according to use category (domestic (no licence) or industry (e.g. irrigation- requires licensing)), location and method of withdrawal (WRC, 1998). The reforms to this act, which came into affect on the 10th of January 2001, took more than four years to develop (WRC, 2001a) and it was as part of this reform that the exclusion from licensing of bores used for domestic purposes, firefighting and watering of stock (non-intensive) were applied (WRC, 2001b). This restored common law access to groundwater for such uses in Western Australia, however the government emphasises that the use of groundwater is a *privilege, rather than a right,* bestowed upon the landowner by the Crown (WRC, 1998, p.18). This has been described as a "*usufructuary*" property right which is essentially a person's right to enjoy something in which that person has no property (WRC, 1998, p. 5).

The notion of property rights and the degree to which people perceive ownership over the groundwater resource beneath them will be explored in this research project. The degree to which people feel they have ownership over their resource would provide for a preliminary exploration as to whether or not they perceive it as a common property resource.

1.2.2 Researching Environmental and Water Perceptions.

Traditionally the psychology of perception was mainly concerned with how *objects* are perceived, whereas in the case of environmental perceptions, the subject is the center of an individual's relationship to the environment (Fischer, 1997). Environmental perception relates to a specific process through which space is perceived and reconstructed mentally, these perceptions are complex, dynamic and unique and is influenced by numerous interrelated factors including location, personal experiences and background (social and cultural norms etc.), and the individual's interaction in the community and the environment (Broderick, 2007; Fischer, 1997).

As a person's perception is his or her own experience, researchers do not have direct access to these experiences, therefore perceptions are usually measured indirectly (Gifford, 2002). For this research project somewhat of a phenomenological approach was used, a method whereby the observer tries to perceive the essence of a setting in a qualitative way will be used (Gifford, 2002). Environmental perceptions are increasingly being recognised as a fundamental part of environmental management, because how the environment and its resources are perceived will influence how an individual or group will act in it, and therefore ultimately affect the condition of the environment (Broderick, 2007). By exploring the perceptions people have towards the use of the environment and natural resources, this may further assist in understanding people's behaviour, as well as gaining an insight into their values, beliefs and/or assumptions that lead them to perceive things the way they do (Buyers, n.d.).

As identified within the Draft report on Perth's Groundwater Demand to 2020 (WRC, 2001) many of the previous water use studies undertaken around Perth, predominantly referring to those done over the eighties and nineties, did not cover private or self-supply in adequate detail. Literature reviews to date (predominantly web-based and journal searches) have so far revealed that few previous studies have researched into the perceptions domestic groundwater users have in relation to groundwater resources in a manner similar to which is being approached here. Many local water-use studies and reports found, including the Water Corporations Domestic Water Use Study of Perth 1998-2001, which updated that done in 1981-82 (Loh & Coghlan, 2003); the 2007 State of the Environment Report-Water Use in Settlements (EPA, 2007) and University of

Western Australia Honours Thesis by Troy (2007), researched aspects of water use in relation to general water use behaviour, predominantly by quantitative means.

Other reports include the water supply strategy for Perth and Mandurah to 2021(Water Authority of Western Australia, 1995 cited by WRC, 2001c), the Survey of Bore Ownership in 1995 (WAWA, 1995), the 1997 the Water and Rivers Commission produced a project entitled "Allocating Water for Perth's Future" (WRC, 1997, cited by WRC, 2001c).). In 2000 the state component of the National Land and Water Audit addressed water availability and water demand for Western Australia (WRC, 2001c). The household sector contributed to the use of 46% (271 GL) of the total water use in Perth (surface and ground), of this it was estimated that 33% of the water is sourced from over 100,000 private bores (WRC, 2001).

One of the more recent qualitative reports undertaken in relation to the Gnangara Mound, prepared by Beckwith and Associates (DOE, 2005) for the Water Resources Division of the former Department of Environment (now Department of Water), explored only 'stakeholder' issues and perspectives. Under the 2001 amendments to the RIWI Act users who abstract groundwater for domestic, stock drinking water or fire fighting purposes are not required to hold a license to abstract, therefore are not considered 'stakeholders' for inclusion in such Government reports looking at somewhat similar groundwater use issues as this project proposes to do.

Among other international studies that explored, to some degree, people's perceptions of groundwater, in relation to what they know or don't know, included that by Suvedi, Krueger, Shrestha, and Bettinghouse (2000) in a study they conducted on 663 Michigan residents' knowledge and perceptions about groundwater. They had conducted this research to assist in developing an educational program wherein the information gained would provide baseline information upon which the program's impact over time could be compared (Suvedi *et al,* 2000). They argued that people should be aware of the issues and conditions surrounding the quality of local water resources and that educators must understand people's knowledge and perceptions of groundwater to teach them about its protection. A lack of knowledge was shown in their study, further enforcing their idea that a state-wide educational campaign for Michigan citizens on the facts about groundwater was needed.

The fact that perceptions towards the environment are increasing in importance in relation to sustainable natural resource and environment management (Broderick, 2007), and that no similar studies have yet been found to exist in this context, helps to build the case for the necessity and benefits of research. The research proposed here, may bring benefits to the natural resource and environmental research and management community. The information this project seeks to explore could provide a basic understanding of the range of perceptions existing among the domestic groundwater use community, this could lead to further qualitative studies to explore particular aspects further or to guide quantitative studies.

As licensing is not required by domestic users, there is often little notification received by the State in regards to new bore installations. The recent introductions of the Water Wise rebates for bore installation have however seen to an increase in people informing the government of their intentions (W. Vanapulous, personal communication, August 27, 2008). As the locations of domestic bores are scattered and also relatively unknown, monitoring of use is a difficult task, and considering also that domestic bores are not metered it can also not be known exactly how much is abstracted by domestic users. As there have been numerous campaigns encouraging bore installation and use as a means of decreasing scheme supply pressures (and costs for the Water Corporation), it felt important that we should begin to explore what this user group perceives of a few of the basic principles of groundwater resources, use and management around Perth.

If groundwater resources in the future require more stringent management (as they probably will) the behaviours and perceptions of groundwater users must be known in order to effectively target any campaigns to alter water use behaviour (Buyers, n.d).

1.2.3 Qualitative Research Methodologies.

A qualitative and somewhat phenomenological approach has been taken to the research project as this methodology is considered a valuable research technique in providing rich descriptions of phenomena (event; aspect; situation etc.) (Gifford, 1997) by "*allow[ing] people to speak in their own voice*" (Sofaer, 1999). Therefore, ones capacity to describe phenomena is enhanced as they can explain and describe it through their own words and interpretations (Sofaer, 1999).

The qualitative approach differs from quantitative research methods which employ deductive logic, usually draw heavily on existing prior knowledge, usually to develop hypothesis, and then go on to test for confirmation or disconfirmation of that hypothesis, producing results usually in the form of statistics and numeric data (Newman and Benz, 1990).

There are numerous texts (for instance, Bernard, 2002; Robson *et* al, 2001; Frankel & Devers, 2000; Sofaer, 1999; Newman & Benz, 1990; Neuman, 2000), which provide instructive details to assist qualitative researchers in the development of research questions, data handling, coding and analysis techniques. These texts (and others) have been drawn upon to develop this research project.

Characteristics of Qualitative Data Analysis (Guilfoyle & Hill, 2002):

- Pervasive: *Not* a discrete activity or phase of the research.
- Iterative and cyclical: *Not* a linear or mechanistic process
- Inductive: Qualitative analysis is often strongly inductive in that concepts and ideas are drawn from, or led by, the data itself. However, there are times when one moves into deductive mode. (e.g. to search for evidence of particular concepts that are defined in the relevant research literature, or verify a proposition about the relationship between two phenomena).
- Creative and intuitive: qualitative analysis being subjective and interpretive, there is ample scope for displaying creativity and originality of thought and expression. Also play's a part in analysis.
- Rigorous: one is required to explain and justify analytic choices and demonstrate that chosen methods were used with due care and consistency.
- Heavily time consuming: Qualitative analysis is a time consuming process and will almost certainly take longer than expected to complete!

The semi-structured qualitative interview technique adopted for this research, will make use of open-ended questions as a means of encouraging participants to express, in their own way, their perceptions towards different groundwater resource and use attributes, in the form of a narrative. The semi-structured approach for these interviews is described, by Robson (*et al* 2001. p. 69), as being a "*compromise between standardisation and flexibility*", inferring to its similarities to both structured and non-structured interview styles.

A major distinguishing feature between qualitative and quantitative approaches is the way in which the research phenomenon is identified for inquiry (Minichiello (*et al.*, 1995, p. 10). The focus is not to reveal causal relationships, but to discover the nature of phenomena as humanly experienced or perceived (Minichiello *et al.*1995). In this method of research, data from participant observation, interviews or oral accounts are studied for themes in the natural language of the participant (Minichiello *et al.*1995, p. 11).

Two predominantly referred to models for qualitative data analysis include those produced by John Seidel (Figure 2) and Miles and Huberman (1994) (Figure 3). These models assisted in clarifying the methods to be used for qualitative data analysis. The first model (Figure 2) was designed to show that there is a simple foundation to the complex and rigorous practice of qualitative data analysis (Seidel, 1998, p. 1). The result was the idea that qualitative data analysis is a symphony based on three notes: Noticing, Collecting, and Thinking about interesting things (Seidel, 1998, p. 1).

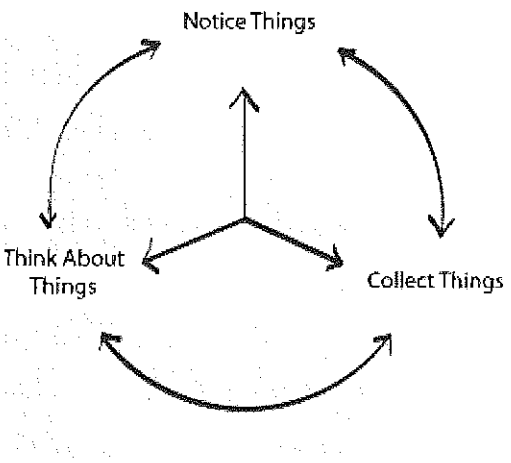

Figure 2: Seidel's (1998, p.2) Data Analysis Process.

As Figure 2 suggests, the analysis process is not linear. When you analyse the data, you do not simply *Notice, Collect*, and then *Think* about things, and then write a report (Seidel, 1998, p. 2). Rather, the process has the following characteristics (Seidel, 1998, p. 2):

- Iterative and progressive: When *thinking* about things one starts *noticing new things* - *collect* and *think* about these new things.

- Recursive: While *collecting* things one often simultaneously starts *noticing* new things to *collect.*
- Holographic: When one first *notices* things one is already mentally *collecting* and *thinking* about those things.

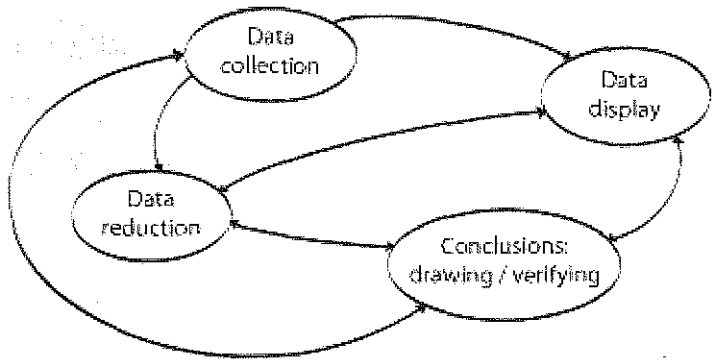

Figure 3: Miles and Huberman's Interactive Model for Data Analysis (Miles and Huberman, 1994, p. 12).

In Figure 3, Miles and Huberman (1994, p.13) have developed a concept diagram to show how the three types of analysis activity, and the activity of data collection itself, form an interactive, cyclical process, also implying a more disciplined and rigorous approach to qualitative analysis than Seidel's model suggests (Hill, 2008).

Coding is one of the most widely known and commonly used qualitative analysis techniques used as a means of reducing, simplifying and 'breaking up' data sets in order to assist interpretation (Hill 2008). Coding helps in the exploration of connections among stories; it helps to identify what is being illuminated; and what themes and patterns are taking shape in the data (Glesne and Peshkin, 1992).

As Miles and Huberman simply put it, "*coding is analysis*" and they see codes as "*tags or labels for assigning units of meaning to the descriptive or inferential information compiled during a study*". They note that codes can be attached to 'chunks' of varying size - words, phrases, sentences, or whole paragraphs, connected or unconnected to a specific setting or theme (Miles and Huberman, 1994).

The elements or units considered useful for analysis, as per Minichiello *et al* (1995, p. 252) include words; concepts; sentences; and/or themes. Ideas for coding can come from a wide range of sources (see Hill, 2008, p. 10-11; Minichiello *et al.,* 1995, p. 258)

including the research question; the theoretical framework; the nature and characteristics of the phenomenon being studied; perspectives and definitions of the participants, and; your own preliminary analysis of the data (recorded as annotations, memos, diagrams, etc.).

Hill (2008) points out that there is no real single, agreed upon, way to go about coding. The procedures or approach that is ultimately adopted will be influenced by a number of factors, including the nature and volume of your data; your theoretical framework; your academic discipline; and your experience in coding and the research topic (Hill, 2008).

1.3 Research Aims and Objectives.

The aim of this project consists of exploring the perceptions domestic groundwater users have towards groundwater resources, use and management around Perth, in particular, the Gnangara Mound. Following a literature review it was decided that the qualitative approach would be taken so as to gain a deeper understanding on the perceptions people have in relation to groundwater.

The data generated is not intended to provide for generalisations to be made, but rather will give an idea into the range of perceptions which may be present throughout this community (groundwater users) at large. The aim of this research, through using qualitative methodology, is not to provide numerical data, but rather to provide data more in the form of a collection of personal narratives relating to individuals groundwater use and their perceptions to the resource. The data collected is not intended to allow for generalisations to be made, nor to act as being representative of the perceptions that may be present across the broader community.

This project will assist in future research by contributing to the knowledge base for the generation of theories, or hypothesis, about domestic user's perceptions to groundwater use and what factors may influence these perceptions (i.e. lifestyle; knowledge) and furthermore, how these perceptions may influence behaviour. It may also assist in the sector of Natural Resource Management as it may highlight new emerging issues or the need for further study into this area as how people perceive resources ultimately affects how they behave towards those resources.

In order to achieve this aim it has been proposed that the research project will be undertaken in two stages. These will be discussed in the following methods section.

Stage One: Interview technique development

- Pilot Tests and Reviews.

Stage Two: Data Generation:

- Final Interviews and Data Analysis.

CHAPTER 2:

METHODS

2.1 ADDRESSING RELIABILITY AND VALIDITY.

Concerns about reliability and validity apply to qualitative data, just as they do to quantitative data (Robson, *et al.,* 2001; Newman & Benz, 1990), but the way in which they are applied is where the differences lie. In a nutshell, reliability is often taken to refer to the dependability or consistency in the research methods, while validity refers to the 'authenticity' of the research: meaning, in part, to give of a "fair, honest and balanced account of life (or some aspect of it) of from the viewpoint of someone experiencing it" (Neuman, 2000, p171).

As qualitative research projects usually study processes that are not stable over time, this can create difficulties in achieving any great consistency between cases (Neuman, 2000), thus potentially creating difficulties in achieving standard measures of reliability (i.e. consistency in methods). It has been said that many qualitative researchers question the quantitative researcher's rigid quest for standard and fixed methods - they fear such inflexible methods may neglect key aspects of diversity that exist in the social world (Neuman, 2000). Qualitative researchers emphasize the relationship that develops between the researcher and the data over time, with Neuman (2000, p.170) using the metaphor for this relationship as being an "evolving relationship, or living organism (e.g., a plant) that naturally matures".

It is recommended that the reliability of methods and data should be maintained through the use of a journal as a means of maintaining an audit trail (Newman & Benz, 1990). In this study my journal (adapted from Newman and Benz, 1990) included notes and reflections including personal (project related) thoughts, analytic memos (see below), advances in theoretical framework and concept building, peer-review (supervisor/consultant) and meeting notes, and advances in design - from the research question design phase, through data collection, analysis and into the interpretation phases. Although aspects of the study may change over time, keeping a journal allows the researcher to describe when, why and how these changes came about over time and would assist in the replicability of the study (Newman and Benz, 1990).

Analytic memoing was also undertaken as another means of addressing reliability and was included in the journal as a means of maintaining an audit trail (Newman & Benz, 1990). Miles and Huberman (1998) describe memoing as being one of the most useful sense-making tools in qualitative research, by allowing a researcher to make note of thoughts and comments can assist in building on ideas from the data – as well as for keeping track of my train of thought regarding different aspects of the study. Both the memos and the journal allowed for thoughts and ideas to be recorded and revisited, which assisted in concept development and results discussions as it helped to further develop thoughts on what the data had meant (Glesne and Peshkin, 1992).

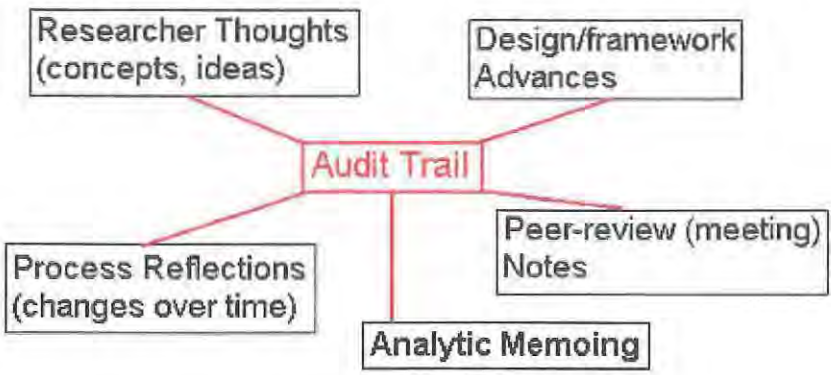

Figure 4: Addressing Reliability - Basic Constituents of Audit Trail (adapted from Robson, *et al.*, 2001; Newman & Benz, 1990; Neuman, 2000).

The question of validity applies to both the design of the research program and the data collected (Newman and Benz, 1990), known as "internal validity" (Neuman, 2000, p.170) and "external validity" concerns, which address the applicability of the findings to a broader range of people or situations (Neuman, 2000, p.170). As this project is dealing with a specific resource (groundwater) and a specific group of people (bore users in the Perth Suburb of Morley (see section) its external validity is somewhat limited. However, the views expressed by the participants in this study can be thought to represent some of the views that may exist among the broader domestic bore using community across Perth. This project is designed as a preliminary exploration that may help guide future research (i.e. quantitative survey development) in public perceptions of groundwater resources across Perth.

To address these validity issues, seven approaches were adopted: i) a semi-structured themes/question list was used (see Box 1); ii) intensive case studies (by way of interview) of particular individuals were conducted; iii) the data was allowed to 'speak

for itself' and not forced into a framework designed by the researcher; iv) the drawing of early conclusions was avoided; v) 'insiders' viewpoints were conveyed; vi) recorded and discussed truthful accounts of proceedings; vii) and coder reliability was measured through peer reviews. In this last mentioned process (as discussed by Newman and Benz, 1990) other reviewers (supervisor and external party) were supplied the same interview transcript and the coding list and were required to code the transcript into where they perceived the sections and themes to fit. The codes and transcripts were then discussed and the differences noted (see section 2.3.6).

The above mentioned measures assisted in providing validity support for the research methods as it helped to show that techniques were unbiased (interviews undertaken in similar manner), results could be seen as truthful accounts and interpretations could be taken to be no, or little, different to how others may interpret them.

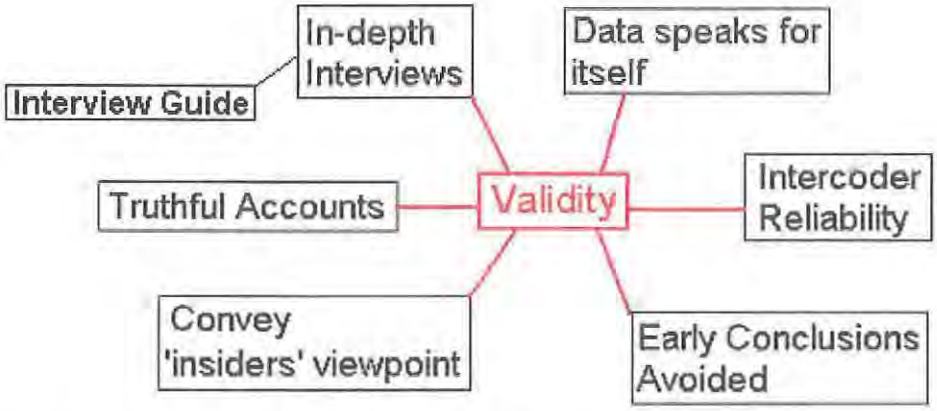

Figure 5: Validity considerations (Adapted from Robson, *et al.*, 2001; Newman & Benz, 1990; Neuman, 2000).

2.2 Stage 1: Interview Guide Development and Pilot Testing.

To assist in the development of the interview guide, and as is common practice, it was necessary to conduct a number of pilot tests, as a means of trialling question ideas and interview methods (recording, introducing the topic, ending the interview and post interview conversations, etc.) and also as a means of determining average interview length. The results from, and further discussion of these pilot interviews (7), and how they shaped the final interview guide, can be found in Appendix C.

As well as testing the ideas and questions, the pilot tests also assisted in the development of an organised system for recording data, as Neuman (2000, p. 240) recommends one should "devote serious effort to pilot testing any apparatus that will be used" (eg., audio recorders, video cameras, etc.). The pilot studies also helped to provide early feedback (as per Keats, 2000). The idea behind pilot tests, as pointed out by Glesne & Peshkin, (1992, p.30), is "not to get data *per se* but to learn about your research process, interview schedule, observation techniques, and yourself".

To practice using the apparatus, in this case being the digital recorder, various computer programs (QSR Nvivo 7, Express Scribe, etc.) and consent forms, all pilot interviews were recorded. A number of the interviews were also taken right through the transcription and preliminary analysis phases and those two participants fairly unknown to the researcher were also supplied with consent forms for voice recording (and neither expressed any issue in signing as it did not pertain any information as to where the participant lived (only name and signature required). Transcriptions were also practiced, but took much longer than initial estimates had guessed. It has been said that a hour interview can take up to four hours to transcribe (Miles and Huberman, 1998), however, for me, most cases took approximately one hour to transcribe about 10-20 minutes of interview.

The intentions of the pilot interviews were also clarified to the participants – it was explained that their role was to still answer the questions, of course, but to also reflect on the interview process and the questions asked, suggesting any recommendations for improvements or further clarification. Neuman (2000, p.241) suggests it can be useful to discuss with pilot test participants how they found the interview. For instance, asking 'were you comfortable in this situation?', 'how clear were the questions?', 'are they appropriate?' and 'what else should I be asking?' can help in developing the interview and question design (Glesne & Peshkin, 1992, p.30) and were applied to this research project. Most participants had stated that they were comfortable with the questions being asked, however, none really made any comments on how the interview questions or structure could be improved.

The pilot testing of the interview guide allowed for the development of a range of questions to assist in exploring people's perceptions of groundwater environment, nature, use and management stemming from the initial broad themes for discussion. The

way in which questions had been asked was noted so as to assist in developing the way in which questions were worded. Some new ideas arose out of these pilot tests, including asking participants if they had any previous training or experience in regards to groundwater resources, did they feel any kind of ownership over the groundwater, do they have issues with management or recommendations to improve it, as well as asking about restrictions and groundwater pricing. The pilot tests also allowed for the development of the question requesting participants to draw their conceptualisations of the underlying groundwater environment, as well as to see if the diagrams would be of any use. It can be noted that the diagrams worked far better in the pilot tests than in the actual interviews (see also section 2.3.5).

As Keats (2000, p.76) had stated, more than one pilot study is usually needed before the final version is achieved. How many exactly? To that there's no specific answer, however, should be "sufficient to allow you to explore likely problems" (Glesne & Peshkin, 1992, p. 31). The pilot tests were carried out in situations, and with people, close to the realities of the actual study. In an ideal situation they should be drawn from the exact target population (Morley) (Glesne & Peshkin, 1992) however, for this project it was considered suitable that pilot participants could be sourced from any area, so long as they were over 18 and were the homeowner/renter of the property with the bore. I considered this acceptable as it meant that less time was spent recruiting participants, therefore more time was available for undertaking pilots and reflecting on the processes and experiences.

The pilot tests were undertaken initially using convenience and snowballing techniques, meaning that people known to the researcher as having bores being contacted for participation - similar to Neuman's (2000) concept of *convenience sampling* and Minichiello *et al's* (1995) concept referred to as *incidental sampling*. Others, yet unknown, were 'discovered' by asking friends-to-ask-friends who had a bore – similar to Neuman's (2000) and Minichiello *et al*'s (1995) concept of snowballing.

The pilot studies were also used to test observation techniques, as outlined by Glesne and Peshkin (1992), such as how the participants felt about and respond to being recorded and interviewed. Most had stated they were not particularly worried about being recorded. Self reflection questions (suggested by Glesne and Peshkin, 1992, p. 31) were also addressed as a means of testing myself, as the interviewer, these questions

included: i) how do I present myself; ii) how do I relate to others; iii) and how do I establish rapport. It helped to be friendly, cheerful and 'chatty' as this helped participants to relax, while also encouraging their responses by listening attentively and showing a genuine interest in what they are saying.

2.3 Stage Two: Data Collection and Analysis.

The second stage of the research project was further divided into two parts consisting of (a) undertaking participant recruitment for the final interviews and (b) analysing the data generated using qualitative thematic coding methodologies as discussed in the earlier literature review chapter. The raw data generated (audio recordings) were transcribed into textual formats and were then subjected to systematic reviewing, using a coding system of theme keywords (inserted later in chapter). This assisted in the identification of important features and emerging themes, which assisted in building an understanding and narrative descriptions for each theme.

2.3.1 Data Management.

Before moving onto recruitment and analysis methodologies, it was considered important to firstly address the means of managing the data gathered throughout this study. Miles and Huberman (1998, p.179-210) in their chapter on qualitative data management describe data management as the "operations needed for a systematic, coherent process of data collection, storage and retrieval" (Huberman & Miles, 1998, p. 180). Such data management systems are aimed at ensuring both high-quality accessible data; documentation of analyses carried out (memos & journal); and the retention of data and associated analysis after the study is complete (Huberman & Miles, 1998).

The data management process used for this study, outlined in the figure below, aimed to address the above-mentioned aspects. Although the data collection from literature reviews is not included in this flow diagram, it was an important aspect of this study (regarding methodologies, analysis and meaning of such data) and was an ongoing process throughout this study. This data was stored in computer files according to topic of literature.

The remaining data collection started with the recording of the interviews. These recordings were then downloaded as a digital audio file into a computer (using the Sony

Digital Voice Editor Program) and transferred to the transcription software (Express Scribe) for manual transcription. Once transcribed, they were imported into QSR Nvivo 7, a software program designed to assist in qualitative data management. Once coded and sorted, key theme sections and quotes were imported back to Word documents for inclusion in the results and discussions chapters.

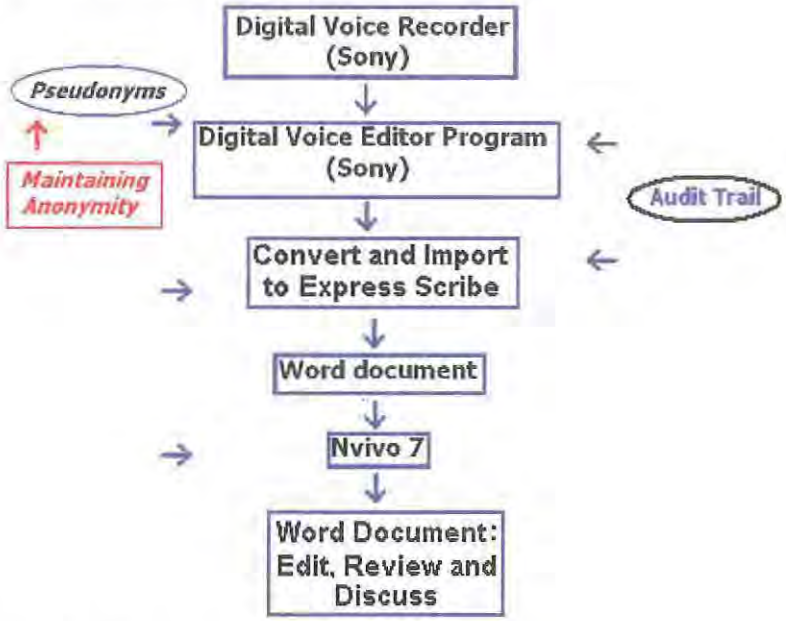

Figure 6: Overview of Data Management Process.

Anonymity amongst the participants was maintained through the de-identification of data sets from the participant, as well as the safe and secure storage of the data compiled. This was achieved by:

- the use of pseudonyms (hypothetical names) applied to define different participants,
- hardcopy records (consent forms, etc.) stored within a locked filing cabinet,
- the electronic copies of data stored only on USB devices, with backup copies saved to CD (data (regarding interviewees) will not be saved to a hard drive of a computer).

Following the use of the data in preparation of the final thesis, the following will be adhered to:

- hardcopy documents will be destroyed (by a method approved by the University Ethics Committee).

- the USB device will be cleared of all content relating to raw data sets and other confidential information.
- the CD copy will be stored for 5 years in a secure location agreed upon by the University and Ethics Committee.

2.3.2 PARTICIPANT RECRUITMENT.

Participants were recruited from the Suburb of Morley, located approximately 8.5km north-east of the Perth CBD. Morley was selected as it has been recognised as one of the four suburbs in the metropolitan are where more than 75% of homes have garden bores, with Morley being the only of these suburbs located on the Gnangara Mound – the larger of Perth's groundwater resource areas (other suburbs included Applecross, Bullcreek and Rockingham) (EPA, 2007a).

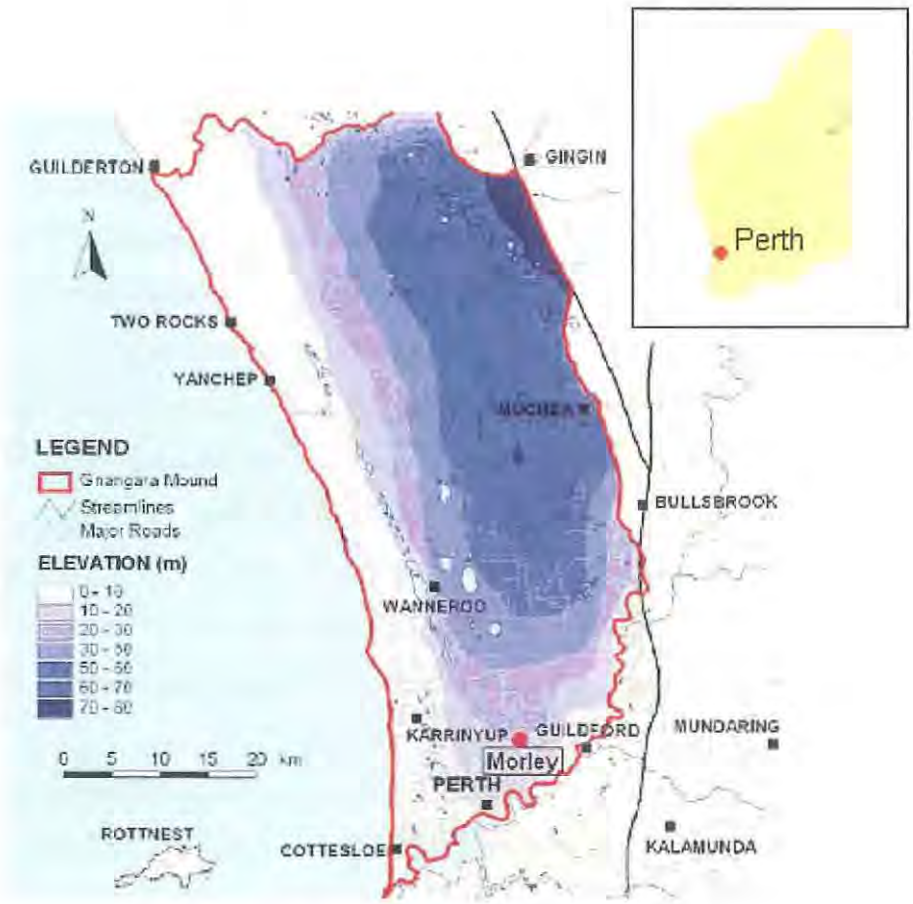

Figure 7: Gnangara Mound boundaries and location of study participants (adjusted from DOW, n.d)

The streets where recruitment was undertaken were selected by considering those where iron staining from bore water usage was evident on paths and walls (red-brown staining resulting from iron coloring in bore water). The only inclusion criteria were that the participant:

- was 18 years or above;
- was the homeowner or primary renter of a property in Morley; and,
- had access to a domestic groundwater bore.

Participants for the final interview round were recruited via contact made through a door-to-door means of seeking willing participants. The method of participant recruitment was similar to what is described as "*purposive sampling*" (Neuman, 2000, p.198). This method of recruiting is often used when a researcher wants to identify particular types of cases, or people, for investigation (Neuman, 2000) – in this case, domestic bore owners. Those identified however are not considered as representative of the broader population but are useful for exploratory research as the purpose is less to generalize to a larger population than it is to gain a deeper understanding of the variety and similarities among cases (Neuman, 2000).

Before door knocking, information letters were distributed to the homes of potential participants.[1] This (information letter) method was also used in a similar study by Story and Forsyth (2008) who used the delivery of information letters, one week prior to their study taking place, to inform residents about their study. Their information sheet, like those prepared for this study, also informed residents of possible risks, costs of their involvement, confidentiality of their records, their rights as participants contact information should they have had any additional questions about the study (see Appendix H). These researchers also used the same door-to-door approach, however, in the case of this study, an in-depth interview was undertaken as opposed to the quantitative questionnaire as used for their study.

The greeting and introduction given when a homeowner answered the door has been included in Appendix E. It generally gave an introduction as to who I was, where I was from, what I was doing and how they could help.

[1] This idea came initially from a pilot participant who had suggested this from experience she had during a study of around 300 farmers within an agricultural region. She found that in the areas where they delivered information letters beforehand, she received a friendlier welcome with the farmers being more at ease.

Initially a target was set to reach between 20 and 30 potential participants accepting to be contacted for an interview, from this group 12-15 people would be selected for the in-depth interview, with the 'richer' (in detail) 6-10 interviews being further analysed as part of the study results. This approach was initially considered as it may help to select a group of individuals of differing ages and genders. However, it was considered that time constraints would dictate a more 'first come-first serve' basis, meaning that interviews would be carried out with every willing participant until such time as saturation is achieved, or more likely, until time ran out. Saturation refers to the full "*taking in of occurrences*" referring that the researcher has done an exhaustive exploration until no new findings occur (Morse, 1994, p. 106). As saturation in this research project may not be achievable, given the restraints on time, a reasonable goal of around 10-15 participants was set, with 12 interviews being undertaken. Of this 12 only 10 interviews were used for analysis as 2 interviews (1 male; 1 female) were lacking in detail with the interviews only having lasted between 7 and 12 minutes. However, it may be worth noting that while these results were not further analysed, they did reveal that there could potentially be some members of the community with very little knowledge and understanding of Perth's groundwater resources.

2.3.3 Interview Procedures.

2.3.3.1 Collecting Data – Audio Recording.

With consent of the participant, the interviews were recorded for later transcribing. This method was chosen, as opposed to taking only written notes, as it allowed for a greater accuracy in the participants recorded response.

2.3.3.2 Before the Interview.

Once the participant had agreed to participate, they were informed that, as part of the University's human ethics clearance requirement, they would be required to fill in a Consent form (see Appendix F). This form sought to make clear to the participant what was going to be done with the data and who may see it.

As mentioned in the section about the pilot tests (Appendix C) most interview situations require a degree of instruction to be given to the participants to *"set the stage"* (Neuman, 2000, p.140). These instructions were worded carefully and followed the same script so that all the participants heard the same thing- thus helping to assure reliability (Neuman, 2000). The overview given (see Appendix E) just explained, in a broad sense, what kinds of subjects may be discussed, as a number of participants had either not yet read the letter or had forgotten what it had said.

2.3.3.3 During the Interview: Interview Guide.

The following page displays the question guide that was used to explore the different themes within the interview. This guide assisted in ensuring the majority of questions were covered in each interview (also helping in times when conversations reach that silent point) (see Box 1).

Box 1: Interview Guide.

(Those in **bold** indicate questions that must be worded in a similar manner each interview or other important notes)

1. Well to start off would you like to tell me a little about yourself and how you came to be living in Morley?
    a. Was the bore already at the property - did any past properties have a bore/rainwater tank – what was/is that like?
    b. Have you installed a bore before – what were some of your reasons? Would you install one again?
    c. Is there a rainwater tank at this property? What is that used for?

2. Have you had any past training or experience working with groundwater resources or been involved in its management?
    a. Have you participated in any forum/community groups over groundwater related issues? What was that like/What were the issues?

3. Next we will move onto a creating a diagram, if you would like to draw for me a diagram that shows your bore and the resource (provide further prompting if required inferring to a cross sectional view) and tell me a little about the bore and what you use it for –
    a. How would you justify your use of the groundwater resource?
    b. Do any of your neighbours have a bore – how do you know?
    c. Have you ever noticed your bore pressure different when they have used their bore?
    d. Have you ever noticed seasonal variations in the quality or quantity of water you bore produces?

4. Next, using this diagram, I would like to explore what you think about the movement of the water through the environment.
    a. **How does the groundwater exist**? Is the groundwater moving?
    b. Where does the groundwater come from?
    c. …Does it go anywhere?
    d. What does it influence and what influences it (i.e. how does the level of the water table influence the environment and how does the environment influence the water tahle etc.)

5. What can you tell me about the groundwater resources around Perth?
    a. Do they mention the Gnangara mound? (**do not prompt for it**) - Do they know its boundaries?
    b. What do you think the current state of our groundwater resources is? (who, where, what why?)
    c. Do you think people are affecting the groundwater resources – (how, who, etc.).
    d. What might happen if the water table was to drop further/over abstraction occurred?

6. **Who do you think owns the water/what do you think about the ownership of the water?**
    a. Why do/don't you feel you have ownership/ why do you think others do?
    b. Who do you think should have rights to use this resource?
7. How do you feel the resource is being managed (good, poor, etc.) (by Government, authorities and the public)
    a. Do you think there are any issues with its management?
    b. Are you aware of which Authorities or Government bodies are responsible for the management of the groundwater around Perth?
    c. What did you think when the bore watering restrictions were introduced – do you think they are reasonable – would you say it changed the way you use your bore?
    d. If the managing body approached you for your feedback on groundwater management (i.e. community forum)– would you like to have an input/attend something like that? What types of things would you recommend or wish to discuss/ask?
8. At the end of the day, who should make the decisions about how you, and others, use their groundwater bores? Why…

9. To finish off is there any further comments you would like to make about the groundwater resources or its management around Perth?

2.3.3.4 After the Interview.

After the interview, the participant was thanked for their time and informed that if they wish to receive a copy of the transcript, that it could be arranged so long as they provided their postal address. A separate form was made for this (see Appendix G) so as to keep address details separate to the consent forms, with participants also being informed that they may not receive delivery for a number of weeks (to allow time for transcription). In the case where I was unsure of something a participant had said (i.e. if it appeared they had been mistaken if said something which didn't make sense with something else), it was highlighted in the transcript where I had been unsure and requested that if my interpretation on what they had meant was not correct it was requested that they contact me. Two participants were asked for clarification, only one replied noting that my interpretation had been correct (this was in relation to Tom (P4) having said his bore went dry in a 'real wet year' – I had asked if he meant dry year instead). The letter accompanying the return of the transcripts has been included in Appendix I.

2.3.4 Data Coding and Analysis.

Miles and Huberman (1994) define data analysis as having three linked sub processes of data reduction, data display and conclusion drawing/verification, as shown in Figure 3, with these processes occurring throughout the data collection phase (Miles and Huberman, 1994). The list below has been adapted from Miles and Huberman (1994) and outlines the process of analysis followed during the research process:

- reflections, thoughts and remarks were noted in margins and within memos contributing to the audit journal. This was an ongoing process and the notes produced were referred back to during the analysis process to help keep ideas fresh in the mind;
- codes were developed, initially based on preliminary pilot test results (interview themes), being further refined during and after the interviewing stage;
- these codes were then used to sort and sift related sections of the transcripts;
- the data was then analysed to explore the commonly held perceptions the participants had in relation to the groundwater environment, the condition of the resource and management and use issues and recommendations for improvement. The implications of such perceptions in relation to resource management were also explored using literature review data.

The code themes developed are displayed below and were applied to the transcripts once transferred into Nvivo 7:

- Context
    - Residence – length of time spent at address (reasons for moving etc…)
    - Bore installation – when the bore was installed/why, or; was it already installed?
    - Experience – anything relating to past experience working with bores or groundwater/water resources.
- Hydrology
    - Perceptions of nature and movement (hydrology/hydrogeology) - Perceptions of the nature of groundwater (how it 'exists') and its movement (does it go anywhere, how does it get there)
    - Boundaries - knowledge/perceptions of resource and boundaries (i.e. Gnangara mound and boundaries)
    - Condition - knowledge/perceptions of groundwater state (in decline/no problem –why?)
- Ownership and Responsibility
    - Ownership and rights - perceptions of ownership/who can use the resource
    - Responsibility/decision making – Who is responsible for their use/who should make decisions
- Management/regulations and use issues
    - Management - who manages (knowledge of managing body)
    - Management issues - do they see any issues in the way its managed/used – what and why
        - management recommendations – any recommendations to solve problems/resolve issues?
    - Regulations - awareness and perceptions of regulations
    - Charges- perceptions to fees and charges on domestic bores

Sections of the transcript were coded to one or several of the above theme nodes. Discussing each of these themes in-depth, based on interview responses, produced the first stage of results. Using these theme narratives, the data was then analysed to

determine to what degree the participants saw domestic groundwater use as a common property regime.

2.3.5 Presentation of Results.

The following results section has been divided into four sections: 1) Participant and Bore History; 2) Perceptions of the Underlying Environment; 3) Perceptions of the Groundwater Conditions; and, 4) Perceptions of Groundwater Management and Use Issues. Not included within the results section is any discussion relating to the diagrams participants had drawn. The idea of developing a diagram of how the participant may perceive the underlying environment did not work as successfully as was hoped (after the success in the pilot tests), therefore they were excluded from further analysis, other than being mentioned when participants had referred to something they had drawn. A majority of the diagrams did not show any below ground dimensions, most only showing details as to the layout of reticulation from the bore.

2.3.6 Addressing Inter-coder Reliability.

To help give an idea as to the degree of similarity shared between the researcher and others in relation to coding interpretations, two transcripts were provided to two reviewers (Supervisor and consultant external to Edith Cowan University). These reviewers were asked to code the interview/s according to the coding list prepared by the research student. The differences that occurred were generally because of overlap between some of the themes (see Appendix B) - certain comments made in an interview could be coded to a number of themes depending on the richness of the statement (i.e. those that referred to many themes within a short series of comments). For instance, there was an occasion where a reviewer had coded a comment to be under the groundwater conditions theme, differing from my interpretation, which placed it within the nature and movement theme as it had shown this participants understanding as to how the system may operate.

2.3.7 Risk Management

A separate risk management plan was developed and accepted, by the project Supervisor and School Safety Officer, prior to any fieldwork being undertaken. The

main risks identified included travel related risks (car accident, break down etc.); pedestrian related risks (while door-knocking i.e. being struck by a vehicle); and risks associated with door-knocking and entering peoples homes (threats, assault, abduction etc.). A volunteer assistant was present during the door-knocking phase of recruitment, however they remained outside of the home (e.g. wait in a car outside) so as not to introduce any bias or influence over the researcher or participants.

CHAPTER 3:

RESULTS

3.1 PARTICIPANT AND BORE DETAILS.

3.1.1 PARTICIPANT DETAILS.

Out of the ten interviews that will be used for analysis in this thesis, six participants were male and four were females. All the male participants (Joe, Bob, John, Tom, Bill & James) were retirees (65 years +) either living as bachelors (Bob & Tom) or with their partners. Out of the female participants, Melissa and Claire were the youngest of the group, estimated to be in their late 30's- early 40's, and followed by Susan (60's) and Judith (70-80).

Judith was wheelchair-bound and living alone in a purpose-built house. As homebound she also worked from home, being a believer in earning your own way through life "*faith without work, I don't believe in*". Only one participant (James) was a renter at a property with a bore and although he had only lived at that address for a relatively short period (2 years & 2 months) he had lived in the same street for quite some time before that. All other participants had lived at their current address for between 16 and 50 years.

Table 3 gives an overview of the participants and their interviews along with relevant information including details on property ownership and length of residence; whether or not they had installed their bore, and when it was installed. Note that pseudonyms have been used to maintain participant anonymity.

Joe and Judith had moved to their current properties after previously living in the country on a farm. Two participants had moved from areas nearer the city (Maylands and West Leederville) where they had been living in a unit (Bob) or a small house (Susan) respectively. Tom, after first purchasing his current property, spent 11 years in eastern Australia before returning and has spent every year there since. Bill had served in the police force and in that role he had spent some time living in Geraldton before buying his current property. Since purchasing the property Bill had also spent a number of years away on country postings.

James, currently renting, had originally moved to the area to be nearer to his children who had lived with their mother after their separation. Over the years he has moved between a number of different houses on the same street. He had also spent some time living in India at Buddhist temples and with Gurus from whom he claimed to have helped him develop a more conservative nature.

Melissa had moved in with her husband after getting married in 1992 and has remained at that address ever since. Claire originally was in Morley then spent a number of years living in the Shire of Wanneroo before returning to this area of Morley as she and her husband "*fell in love with the street*".

Table 3: Overview of participant, interview, residency and bore installation details.

Name (Participant Number)	Age Bracket (estimate)	Gender	Interview Length (min)	Length of Residence	Home-owner/ Renter	Bore Installed by Current Resident	Time since bore installed
Joe (P1)	70-80	M	29	28 years	Owner	No	* 28 + years
Bob (P2)	70-80	M	43	48 years	Owner	Yes	47 years
John (P3)	70-80	M	51	49 years	Owner	Yes	32 years
Tom (P4)	70-80	M	18	48 years (inc 11 years while in services)	Owner	Yes	34 years (approx.)
Bill (P5)	70-80	M	13	48 years	Owner	Yes	45 years (approx)
James (P6)	60-70	M	17	2 years 2 months	Renter	No	** 2 years 2 months +
Judith (P7)	70-80	F	45	50 years	Owner	Yes	49 years (approx.)
Susan (P8)	60-70	F	52	41 years	Owner	Yes	39 years
Melissa (P9)	35-45	F	20	16 years	Owner	No	* 16 + years
Claire (P10)	35-45	F	39	16-17 years	Owner	No	*17 + years

*These dates are estimates only, based on the time of residency of the participant.

** Although only renting for 2 years, James had lived in the same street for a number of years beforehand.

3.1.2 Bore History.

Out of the ten participants, six had the bore installed themselves (P2, 3, 4, 5, 7, 8), with four of them being directly involved in the installation (excluding, 7 & 8). These other two bores were installed by other members of the participant's family: by an uncle for Judith, and by the husband and father of Susan, without the direct involvement of the participant themselves. Out of the four who were directly involved, the installation was also something of a family affair, with participants getting assistance from brothers (Bob), sons (Tom & Bill), and with Tom even having a water diviner (an uncle) who helped choose the location of the bore. John had assistance instead from a "*mate that was in the game*" at that time. These six bores have been installed for between 32 and 49 years. The date of installation of the remaining four bores is unknown, as the bore had already been installed prior to the participant moving to the property.

Of the participants who did not install the current bore, Joe mentioned how he "*inherited*" the bore as a shared resource between his property and his neighbours'. He said that the shared arrangement "*was a bit of a lack of privacy*" and that after a few years, when his neighbour would not assist in maintenance costs, he coupled the line back, disconnecting his neighbour. John had also started out by sharing his neighbour's bore before installing his own.

Judith also stated how she had offered her neighbour at the time the option of sharing her bore, however, "*for reasons best known to him*" he had declined. Susan was the only participant to be currently sharing a bore with a neighbouring property – which her father lived on. James, although living in a unit complex, was the only one who operated the bore as his unit had the only adjoining garden (front lawn).

Participants reported depths of the bores from 12 feet to 100 feet – although these two extremes were guessed estimates by Susan and James (neither involved in the installation). All bores were also connected to reticulation systems with John and Tom specifically mentioning it was connected to a reticulation timer (others may have had timers attached but did not specify this in the interview).

Bob and John had stated there bores were around the 30 foot mark (Bob 33 feet) with John saying he had stopped at 30 feet, "*we actually hit something and couldn't get*

through it" which he has assumed to be second layer of coffee rock (see section 4.2.1). Joe and Judith had thought that their bores were around the 60 foot mark while Melissa and Claire did not really have any accurate idea of how deep their bores went, with Claire estimating perhaps "*it's a couple of liners down*" - unfortunately it was not clarified what exactly was meant by 'liners'.

Most participants had relatively large blocks, considering the area was established around the 1960's, with the larger blocks being around 900 square meters. Joe, Bob, John and Tom were situated on some of the larger blocks, followed by Judith, Melissa and Claire (Melissa and Claire in a slightly newer area) with James' block being considered the smallest seeing as much of it was covered with buildings or paving as it was part of a unit complex.

3.1.3 Reasons for Installation.

The reasons for installing a bore appeared to revolve around the value the participants placed on gardening and having green lawns and gardens as well perceived monetary savings from using bore instead of scheme water.

Bob expressed this when he had said he installed it because he had "*green thumbs*" and a block size on which he could grow his vegetables and fruit. He added also the advice his brother in law had given him:

> ...my brother in law... [Who had] put down a bore before... [had said] if you are going to do some gardening you need to have your own water supply.

Bob said he didn't have a rainwater tank but he used 200L drums and an "*old boat*" to collect rainwater to use on his pot plants. He said he did have intentions of installing a rainwater tank, however was waiting upon his sons' arrival home from serving in the forces overseas, as he would require his help.

Block size appeared as a factor influencing John's decision to install a bore:

> ...We've got a fairly big block , plenty of lawn and it was difficult to water with a hose and sprinkler, you know, you were shifting sprinklers all the time.

John mentioned also that his neighbour installed a bore first and they used to share it and run a row of sprinklers from in the back yard. John later in the conversation simply put it down to:

> We've got the lawns, we've got the gardens and we want to water it...it's cheap once you've got it, ...it doesn't cost you anything to water the lawns, other than a little electricity.

This statement adds a monetary dimension to installing and using bores. Once installed, they are relatively cheap to run. John, when talking about rainwater tanks, mentioned the convenience factor involved in having a bore:

> ...Sure we could probably put a water tank in, even if it was only used on the garden, but you wouldn't, you'd miss your bore, the convenience factor is just not there, you, know, you get lazy.

Tom had said in his interview that he put the bore in shortly after 1974 so as to maintain the garden during the dry times after they had had a few dry years. He also mentioned that since then, the bore had only gone dry once and that it occurred during a very dry year, however, he could not remember which year.

Bill was another, like Bob and John, who mentioned block size: "*it's nearly a quarter acre [the block]... we've got a lot of grass at the front and a lot at the back*". He further added he found it cheaper and easier overall to do it this way and install the bore than run from scheme water, being another who inferred the relative cheapness of using bore water on the garden.

Judith said her reason for installing the bore was because she had "*particularly wanted a garden... because I'm a farmer's daughter ...I looked out and, you know, it was just sand and I couldn't understand it*". In the process of establishing her block, an uncle of hers had said "*Judith you need a bore*", and with that she gave him the money and he and a few other uncles installed the bore for her. Judith did not make mention of any perceived financial savings.

Susan referred to the financial savings and block size:

> Mainly because we thought we'd be better off to use groundwater to irrigate that to use the...fresh water, and also because it's probably cheaper for us to do it that way ...and we've got a big block so to be able to water everything it was a lot cheaper to water it that way and keep the other water for drinking or cooking.

Susan also mentioned that the bore water seemed better for the gardens as she noticed that gardens watered by bores always appeared greener and healthier looking. When

asked later why it would be better using groundwater than scheme water Susan had responded, "*well if they go to scheme water, we haven't got any water have we, we've got a problem with our water, our scheme water because...we don't get the rain and... the rivers are drying up*".

3.1.4 PARTICIPANT EXPERIENCES.

In the early stages of the interview the participants were asked if they had had any experience or training before dealing with groundwater. Joe had previously been a farmer in the West Australian town of Meckering. While on the farm he had used windmills and bores to get his water, saying that he "*wasn't in dam country*" as rainfall was not sufficient to catch nor was there enough clays in the soil. On the farm he had also used water diviners to find 'underground streams' in which to sink a bore. It appeared that he thought of himself as a water conscious person and attributed this to his experiences as a farmer:

> ...I know how valuable it is, being a farmer...I'm used to conserving water...I've had to find it, I've had to utilise it...using it just when I need to and nothing more, I've never wasted water.

Joe also spoke of his interests in geography and travelling, enabling him to experience much of Australia and he therefore had plenty to say about the state of water resources nationwide. He spoke of the Murray Darling and its many tributaries; the Snowy River scheme; artesian and sub artesian aquifers; other eastern state rivers and their conditions; and the Ord River and the 'pipeline to Perth' idea – of which he didn't agree with as he felt "*they would exploit it like they've done with the Murray Darling*" if it was not properly controlled and managed. In his days on the farm Joe had participated in community groups who were working to combat the effects of salinity in the area:

> Only local salt things that used to come up...I was interested in that to the extent of planting a few tamaris trees along a salt wash to try and contain it from going any further, and it was partially successful.

He added that he had been out of farming for around 30 years: "*So I'm a bit out of date with what's happening currently*". Joe had mentioned that while on his farm in Meckering, 2 – 3 months after he had installed the bore, a large earthquake occurred in

the area in 1968 after which his bore went completely dry, "*So they [groundwater] do move by earth forces*"[2]

Judith had also grown up on a farm, and when asked of her past experiences with groundwater, she told me how her parents were farmers and her brother is still on the farm and how she felt it made her appreciate water more:

> ...when it comes to saving water, I'm an absolute expert...In my younger days I remember my father having to cart water at 4 'o' clock in the morning to avoid the evaporation...he used to cart it on a dray and bring it and put it in our tank on the farm...because we were without water on the farm, we were dependent on tanks...It takes somebody like me that's grown up on a farm that had to watch father carry all the water, you know, that really values it...

Tom spoke of his time in Vietnam where he was an engineer, "*one of my jobs was supplying water to the task force...that was from deep water bores*". James time spent with a Guru in India in his younger days was influential:

> ...the Guru who was in charge of it always said 'they say that there's not enough water...but you people don't know how to conserve it...enough said and I've always thought of that.

Claire was the only participant (apart from Joe) who had mentioned having a bore before when previously living in Morley (spent time living in the Shire of Wanneroo, before returning back to Morley about 17 years ago). While in Wanneroo she said her and her husband had contemplated getting a bore, but found out it would need to be very deep and would have cost too much, "*so we just had a bush garden instead*".

3.1.5 SUMMARY.

In a report produced for the Minister for Water Resources, by the (former) Water and Rivers Commission (1997), it noted that "*a very large number of garden bores were drilled in the late seventies in an effort to circumvent the water restrictions*". Among these participants, a number of their bores were installed prior to the scheme water restrictions, introduced in the mid seventies, with only 2 (John's & Tom's) being known to have been installed in the late seventies. Looking at the data here, many had installed

[2] An earthquake occurred in Meckering on the 14th October 1968 that measured 6.9 on the Richter scale (Gordon & Lewis, 1980) and was accompanied by surface faulting extending over an area of 200 km2 (Gordon & Lewis, 1980). The Meckering Fault was actually the first tectonic ground breakage to be recorded in Australia (Gordon & Lewis, 1980).

the bores as they valued a 'nice' garden or the enjoyment of gardening, on their big block.

In the 2001 draft report for the Water and Rivers Commission, entitled *Perth's Private Groundwater Demand to 2020,* a survey of 761 households across Perth was undertaken and the following had been some of the more prominent advantages to installing a bore (WRC, 2001):

- scheme water too expensive;
- can use more water/no need to worry about the cost of water;
- saves demand pressures on the scheme water system;
- better for the garden;
- convenient and time saving;
- enables you to get around scheme water restrictions.

A number of the above-mentioned responses were found in the data here, excluding however the last point as restrictions apply to the use of domestic bores now too. The water use by those participant's who valued gardening, or having a nice garden, was considered likely to be greater than those who don't have those values. In studies by Syme, Seligman and Thomas (1991, cited by Syme, Nancarrow & Seligman, 2000, p. 567) and Clayton (2007), they had found that the attitudes toward the "value of gardening as recreation and as a means of increasing resale were significant predictors of household water consumption". This aspect would require consideration in efforts to manage domestic water use as people may hold the value of their garden higher than the risk they perceive of degrading the groundwater resource.

From the data received in the interviews the background experiences of participants were wide ranging. The majority appeared to have lived in or near the city for much of their lives with only Joe and Judith claiming to have grown up on a farm. Joe remaining there up until 30 years ago, with Judith having left 50 years ago.

3.2. Perceptions of Groundwater: Nature, Movement, Conditions and Influences.

This section explores the views and perceptions of participants in relation to how groundwater exists and how water cycles in the environment. This topic was explored during the interview and statements that built an understanding on, or explored the

participant's understandings of the nature and movement of groundwater were pieced together and have been described below for each participant. Some comments have also been included in discussions below if they appear to be representing a possible understanding or misunderstanding of the nature of groundwater or its role in the environment.

3.2.1 Knowledge of Underlying Environment and Geology: Presence of Coffee Rock.

Joe, Bob, John Tom Bill, Judith and Susan all mentioned the presence of coffee rock, with Melissa less specifically saying that there was rock in the area, *"I assume that there would be [rocks] because I know that this is, like, swampy area".*

Although Joe did not install his bore himself (by previous owners) he felt he knew a little about the underlying geology:

> Well underneath there is that coffee rock, I know that because I've seen when they put the sewerage in at the back, they dug up coffee rock, so you go through that to something underneath it with mostly sand on top and underneath that you get into the groundwater, and I think it's pretty much common right through this area.

When Joe was prompted on how he perceives the groundwater, he responded:

> There's various ways it could move, it could move through an underground stream or it can be a reservoir just encapsulating the water, encapsulated in an area that you can draw on...
>
> I don't think it's sub artesian here, it could be but I don't know... I know there is an artesian basin in the Perth area, I'm just not sure whether we are tapped into it...

Bob remembered that there was a layer of coffee rock at four feet and thought that perhaps as water is extracted that a cavern may be created: *"when they [the bore spear] get down to the bottom, of course when you extract the water that would create a cavern down there, I should imagine"*. Asked on whether he thinks it's flowing, he commented:

> ...I think it's just a great big puddle down there...because we haven't got a running stream, but it's got to go somewhere I suppose.

John remembered hitting coffee rock within 3 feet of the surface before reaching another layer at 30 feet that they could not break through. John also explained how the water exists within "*water bearing sand*":

> ...there's water in the sand...this is the reason for the slotted pipe [on the bore], that just stops the sand coming in, but it sucks the water out from the area...it's water bearing sand, and depending on how your sand is, is how efficient the bore [will draw water]...

Tom stated that he had gone down through 2 layers of coffee rock before ending his bore at 40 feet; adding "*I think it's [groundwater] just laying there through the grains of sand*". Bill referred to coffee rock as the reason for the staining in the water, saying:

> ...we tried to get away from the smelly and stained water, but it didn't work unfortunately... there's a lot of coffee rock around here...

When Bill was asked for his ideas on how the groundwater exists, what kept it there for example, he said "*I think it's just nature...I mean what else could I say because it doesn't seem to be, well the supply doesn't seem to get any less*".

James' thoughts on the groundwater was that it existed between the "*rocks and sand... I guess you would call them underground rivers... I don't know*": how it was contained he did not know, thinking that perhaps it doesn't disappear because "*it's always raining*".

Judith had mentioned, while discussing the installation of her bore, that the first thing they struck was coffee rock "*and when they got through the coffee rock they got to the water*" and thought "*it just welled up through the sand*". Susan's references to coffee rock came while she had been speaking about how the coffee rock stops the water rising up too far under her swimming pool:

> We do have coffee rock around here...that keeps the water level down and doesn't allow it to go through the coffee rock to get to your [swimming pool] water, you know?...whether there's more rock under that I don't know

Melissa thought:

> It comes through the rock...it might be like a stream, an underground stream or something like that...thinking about the Gnangara mound, which is like a reservoir, so I think that's like streams where water has gone down through the rock and it's like a river... I think it's flowing through the rocks, I'm not sure if there's air there at all...

Claire on the other hand felt that there was no rocks in the area "*just sand*" and that perhaps there was a sandstone layer (or something similar) underneath which held the water where it is, although she admitted she "*never gave it much thought*":

> It's not down as far as rocks here, there are no rocks, there's just sand, I don't believe there are rocks because that's not very deep down... ...there must be some sort of pockets of water that we are able to tap in, I just mean it's sandy in between, that we are going through to get down, but I mean it must be some sort of a sandstone in the bottom of it to hold it... but it can't really be sucking it out of the sand because the pump wouldn't be able to extricate it at the level that it's coming out through our bore, so there must be pockets of water...not necessarily caverns...it's much too close to the top...but maybe just little strips of channels of water that collect up in little places...

3.2.2 Perceived Depths to Groundwater.

In reference to the depth of the water table, Bob stated the water table started at 7 feet, although he thinks it is now further down. John mentioned he had struck water at three feet but since the drainage channels were installed, he thought it was about 11-12 feet down now. Tom remembers reaching the water within 8 feet, and thought this was still accurate judging by the depths of water in local drainage soaks:

> ...the top of that water [in the drainage soaks] is only about 4-6 feet below ground level, in each case, so that gives you, me a fairly good idea of what the water level here is, probably still at about 8, maybe 10 feet.

Judith remembered her uncle (who installed the bore) hitting water at 8 feet and recommended going deeper, where he had said "*you'll get a better supply of water*". The remaining participants did not mention any depths to groundwater, however, most participants did recognise that the area used to be swampy and that the water table is relatively high.

3.2.3 Perceptions of Water Cycling and Groundwater Movement.

Most participants made numerous statements on their perceptions of how they feel groundwater exists and how it may move. Joe made several comments that indicate his awareness and understanding of the nature and movement of groundwater. His first was

about 'forking'[3] bores, something he admitted to doing once before when he had too many sprinkler stations on at once during a dry year, adding that "*some of the other bores around the area I know...they turn the pump on too much and they 'fork' the bore because they run it out of water*". He also mentioned after experiencing an earthquake, over the following months his bore became "*dry as a bone*" he had said, adding "*so they do move by earth forces*".

Joe also mentioned how nutrients can move through the "*system*" and feels that pollution in the groundwater would eventually contribute to pollution in the rivers. Where you have good water underground "*you're going to have good growth on top...that's where you get your big trees...that's where you get all your swamps and all your native birds and things*".

On the topic of movement, he felt that there would have to be some, otherwise the water would be exhausted:

> I would think in this situation it would be fairly stationary, but there would be some movement, there would have to be...otherwise you would just exhaust it wouldn't you, if there's not enough rain to replace it...

Joe also mentioned the recharge of the Great Artesian Basin on the eastern side of the country "*most of that water comes from under the ground in New Guinea...so that's where it's replenished from, not from our own rainfall*". Suggesting an understanding of groundwater recharge coming in from elsewhere through underground movement.

Bob said "*you can't see it, you know, but it's down there*" and that rainfall feeds into it through "*general soakage*" but was unsure where the groundwater moved. At one stage Bob said: "*But all the water I'm using... a lot of it just goes back down into the groundwater again*". This conception of the groundwater cycle was also held by Susan who felt quite strongly that the water she uses on her garden goes straight back down. She mentioned this 'water return' concept numerous times:

> ...I think everybody needs a bore, it saves water, I mean, even if you use it, it goes straight back into the ground...

[3] Forking a bore was a term used by a participant to refer to when air is sucked up the bore when groundwater is too low or does not have enough pressure (can be caused from trying to pump too much at once)

...but that water's going back down to the ground you know, you're taking it out but you are putting it straight back into the ground...

...you've got to be able to take it and put it back and the only way we are going to be able to put it back is if it rains or if it goes back into the ground and keeps things moist...

...but if we are putting the water back into our garden, taking it up and putting, you know, keeping it nice and moist, well it's going to be much better than having dry...

In relation to horizontal flow, Susan had stated "*Oh, that I can't say*" and again mentioned the rise in water she notices every year in her cellar (see State of Groundwater). Asked where the groundwater comes from and where it may go, Susan's comments were:

...Well I don't think it comes all from the sky...because I mean there's water under the dessert so, and they don't get much rain right... I think it's been created by God because I believe that there is a God and that's my theory, right, that God created the Earth and the atmosphere and everything ...

I don't think it just comes from the sky because there's some places where there's water other places there's nothing, now in Morley it doesn't rain more that in rains in Wembley, now in Wembley the water levels have gone down right...so it's not that, it's the way in which the place has been made...certain places were created one way and certain places were created another...

John, in discussions about how and why the groundwater is there, made the following series of comments:

...all the water from the septic tanks used to go down, being swamp as well, I mean, the water table was high...the water table from memory used to follow the contours of the land...but now they've put drains in and that has dropped our water table, they put in the drains and then they put the sewerage through...where it [groundwater] comes from I don't know...it's just part of it and that's it, it's accepted, we accept it [laughs]...the water table does go down in summer...we've got a pressure gauge on the wall there and you can see that it drops down considerably...so it is replenished by rainwater...

On the topic of whether it's moving or not:

Oh, well, they said there are streams there but where it goes I don't know...but as I say this was all swamp area so it was stagnant water really...and the drains...at the back of

the Dianella Plaza ...there's a bit of a park there and a lake... this is where the water drains.

John said that the groundwater follows the contours of the land and predictably:

Well I mean, there's water table everywhere, it just, I mean coming up on 75 I've forgotten all that I learnt in school...you know...contours and how the water actually follows the contours in some respects, but you have underground streams and everything but you get a good water diviner and they can actually go around and divine the best place to actually put a bore...

Tom's water divining uncle said to him "*got yourself a stream flowing through here*". Tom said:

Well it's a fair bit of runoff and my way of looking at it, knowing the district from 40 years back, it's soakage from the surrounding areas and the roads and so forth.

He explained that the groundwater is where it is because of "*the make-up of the ground*":

... I think it's just laying there through the grains of sand...as I went down the sand became much cleaner, therefore to me that indicated that there was the flow of water going through there, so there must be a flow going through gradually from here to the ocean.

James estimated that his bore went down about 100 feet "*but I've got no idea how it connects to the water, I just assume it's some sort of a pump that just pumps the water up from down there*". Asked on how it exists, he responded:

It comes from the clouds, I guess, from the rain, the rain and water gets, I don't how it gets there though, I really don't know, I know that it's there or else there would be no bores, they wouldn't work...and I guess you would call them underground rivers I guess, I don't know.

He added later:

Well I would assume, well it would have to seep away unless it was sitting on concrete or something, unless there's some rock or something, no I would assume it doesn't get depleted because it's always raining and the rain somehow finding its way down there...at great depth logically...[and it moves] between the rocks and sand.

Judith had wondered if "*we are in some way attached to the Pine plantation in Mt Lawley*". Later she added:

> Well as I said, I thought it came from the roots of the pine plantation...I thought that the pines were doing good in the community from ah lifting or not is it lowering the water table, but that's what I've always thought, trees help stop the saline bit you see, and my brother on the farm has grown an enormous amount of trees to stop the salt from coming?...

On the topic of where it comes from and where it goes, Judith had stated that "*I thought it just welled up through the sand*" and that "*eventually doesn't it get down toward the Swan River and feed into the river?*"

In discussion with Melissa she claimed that the water feeds through the rock from the rain in "*underground stream[s]*" and felt that it must be moving:

> I think it's flowing through the rocks...if it's a stream I think it would have to be moving, so I would say it's moving...I think there's several ways to go out, to a river, or it could go to some sort of reservoir...

Melissa had not noticed any seasonal variations in either quality or quantity and later commented that her husband (who was an engineer) had explained to her:

> There's something tricky as well with this water, it's somehow related that, my husband was trying to tell me, that if, it's actually a good thing taking the groundwater out, but I can't tell you exactly why.

When similar topics arose with Claire, her responses included:

> ...the water that has accumulated over hundreds of years, this was actually swamp around here, they dried it out to make it...
>
> I think the rainfall would filtrate down through the ground...but I presume that some of it, there are these aquifers aren't there underneath ...I don't think that necessarily we're [in Morley] on top of an aquifer because of the fact that we are in a marsh already considering we are so close to the [Swan] River and I know that the Gnangara aquifer seems to be just about empty...so I presume some of it is aquifer water from way back that's filtering in from other places that haven't got their bores or that are too far down...but I think it takes quite a long time to get down...quite a few years...like if it rains a lot this year it doesn't mean that your groundwater's going to be really high next year, it's from way back, and I presume that it's filtered by the sand and stuff that goes through and that's why it's actually reasonable water that's coming out if it.

Continuing on the topic of movement she added:

> ...but the fact that the rain falls on all of Perth and only certain areas have got the groundwater within reaching distance, it means that it's not just rainwater and it's not just aquifer water.

Claire clarified:

> Well I presume some of it stays there [locked in sand]... but it's finite so I don't suppose it goes anywhere unless you suck it out, most of it will stay there...some of it will go to the trees...but most of it now I suppose is being pumped up by people's bores.

Claire, however, did show a different conception (compared to Bob and Susan earlier) of what you use on your garden:

> I found a plant discarded...and when 'husband' dug a hole to put it in...he said about that much [top few centimeters] was damp and then there's dry, you know, it doesn't go down very far...and that's with having the storm this week...so I know it doesn't go very far.

3.2.4 Knowledge of Resource Boundaries.

This section was created into a coding theme as a means of addressing the degree to which respondents were aware of the groundwater resource to which they have access. Although questions relating specifically to the Gnangara Mound (name and boundaries) were not used in interviews, a number of participants did make mention of it, and when they did, they were asked what they knew of it.

The Gnangara Mound was brought up unprompted by 6 out of the 10 participants (P1, 2, 3, 4, 9, 10). However, most of these participants were unsure as to whether they, in Morley, were overlying it. Claire was the only participant who had directly stated that thought she was within the boundaries of the mound and the question of boundaries was not addressed in John's interview.

Joe's first mention of the mound it was less than certain:

> I know if it's in the local mound here it's part of the Gnangara Mound, I know that's where they supplement all the water up here in the northern suburbs...all along Gnangara road there, all those pumps, they are part of the Gnangara Mound, whether it extends down this way I'm not quite certain...

Joe again brought up the Gnangara Mound when prompted further about Perth's Groundwater resources:

> Well I know that there's the Gnangara Mound and to the south there is another mound under Perth, I think it's called the Perth Mound, but you may have some other name for it, but I believe their sort of connected but separate mound that operate through Perth...

When asked to elaborate, he replied:

> Well I think it goes up as far as Gingin and places like that, I think that's still the Gnangara Mound up there, I know that there's groundwater under Gingin because you see the big sprinklers working up there... All through Gnangara and down probably as far as us, I don't know how far east it goes... I just couldn't answer any more than that.

Bob was aware of the name of the mound, but was also unsure if he was overlying it, "*I thought it was further over*". He was aware that it is used for the scheme water supply: "*this is the water that someone's pumping and we're drinking it*". Of its boundaries he said: "*...it goes up to Geraldton doesn't it...[it's] huge*".

John raised the issues of the Gnangara Mound when asked about Perth's groundwater resources, discussing how the market gardeners on the Gnangara mound are using a "*tremendous*" amount of water and how the lake (Lake Gnangara) has dried up over the years. He brought it up again when asked about the consequences of the water table decline: "*then we could be in trouble with our drinking water, because a lot of that comes from the Gnangara Mound*".

Tom raised the matter of the Gnangara Mound when asked what he knew of Perth's groundwater resources, saying that he has witnessed Lake Gnangara get drier over the years. In relation to the boundaries, he admitted, "*I haven't got any accurate idea of it, but I know it is a fairly large area*".

Melissa mentioned the Gnangara Mound as being "*like a reservoir*" with "*streams where the water has gone through the rock*" and although being she thought perhaps "*several suburbs*", but that it's a "*huge*" area.

Claire referred to the "*Gnangara aquifer*" and was unsure as to whether Morley was situated over this "aquifer": "*because of the fact that we were in a marsh already, considering we are so close to the river*". When asked about its boundaries said:

> It's very big...I don't know whether it goes up past Carabooda that sort of area, down to...here...the Swan River... so then we are on the Gnangara Mound as well, we are taking out of the same thing...so we are all in the same, it's all one, like north of the River is all one

Of the remaining participants (Bill, James, Susan, Judith) the topic of the Gnangara Mound boundaries, or its existence, did not come up during the course of the interview.

3.2.5 Summary.

The data show that there was a commonly shared perception that coffee rock was present in the underlying geography, with a number of participants referring to the depths of these layers at 3-4 feet below the surface, then at approximately 30 feet. Some participants also inferred that the coffee rock plays a role in keeping the groundwater where it is, such as Susan who felt it stopped the groundwater rising too high. In relation to how the groundwater exists, a number of participants referred to underground streams, with many suggesting the depth of the groundwater was between 7 to 12 feet.

Responses to the nature of groundwater resources (where from, where to etc.) were more vague with most participants appearing as though they had never really thought much about it. The fact that we cannot see groundwater, means it is external to most of our sensory organs (except perhaps the smell), and therefore attempting to picture how something exists that you have never seen before, could be somewhat of a challenge. In relation to the boundaries of the resource, the majority of participants had known of the Gnangara Mound, however most could not accurately depict where the boundaries of the mound lie.

3.3 Perceptions of the Current State of Groundwater.

3.3.1 Perceptions of Quality.

Only a few of the participants had mentioned issues relating to groundwater quality, usually in relation to the possible decline in, or influences on, quality.

Earlier in the interview while discussing his bore, Joe had mentioned that it was pretty good water:

> And it's pretty good water...I've never actually had it tested but I know you can drink it, it's not that bad, it's got very little smell. Occasionally we get the swampy smell that you get from this groundwater here...and there a little bit of stain on the side of the house...

However he later added, when prompted for his thoughts on its current state:

> Well they're in a good state, apart from all the pollution that man's putting into it, in the form of oils and run off and things like that, I know that must eventually get down there.

He also mentioned nutrients:

> I know nutrients do get into the groundwater and through that system, but I wouldn't think it would get down into the really deep stuff, it would probably only get into the real shallow stuff, more the swampy water type of thing would pick that up and that would run into rivers and that's how you get your pollution in the rivers.

Melissa also mentioned pollution, "*there's pollution coming down in the rain and infiltrating, and that sort of thing*". Claire made reference to impacts on groundwater quality referring to a sewerage leak in the area, she found that the bore water along the opposite street smelt worse than water from other areas. She thought perhaps those that were not affected were in a different "*pocket*" of water or went down deeper. Later in the interview, Claire also mentioned that nutrients (specifically referring to phosphorus and nitrogen) go down into groundwater as well, and later implied that as the groundwater levels decline, she felt this would create a higher concentration of pollutants:

> ...it's [groundwater] going to get salty and smelly because you'll have the nutrients in it, concentrated rather than more diluted.

For Susan the quality had not changed:

> ...there is a little bit of rust in the water, but that's always been, that hasn't changed".

3.3.2 Perceptions of Quantity.

The majority of participants were aware of some degree of groundwater decline around Perth. Joe, in conversation on the current state of the groundwater, felt " *at the present state I'd probably say they'd be depleted from when they were originally tapped into*". In the interview with Bob, he noted that groundwater levels had declined since he had

first installed his bore, "*the water table started at I think 7 feet below the surface of the ground, it's further down now*", later adding:

> Well when you see the lakes and so forth, it used to be 2 or 3 feet deep, but now, nice and dry and dusty, that means that the water table has gone down and they put that down to no rain and people with bores.

John felt that the groundwater has definitely declined over the years, both locally and at a broader scale. John had mentioned how their local groundwater levels dropped from about 3 feet (at highest, in early days (1960/70)) to, what he thinks now, is 11-12 feet below ground surface, resulting from the installation of drainage lines and a sewerage network. He also mentioned a lake that used to exist in a nearby park, a lake to which he had said "*even after the rain, you're lucky if you have water in it these days*".

Tom noticed a decline only in terms of lake water:

> Lake Gnangara...there used to be quite a lot of water there, in fact, going back maybe 20 years back. They used to have sail boats on it...and now, it's just, well the last time I went anywhere near it, it was just empty... no water there.

James admitted to knowing very little about Perth's groundwater resources "*a very dry place, must be one of the driest cities in the world I would think*" and added:

> I would hazard a guess and say they are probably not very good...I know the dams are never above about 30%, which is very distressing".

This sentiment is expressed by Judith too: "*very very soon we are going to be terribly short aren't we?*". She explained noticing the effects of groundwater decline on her brother's farm in Northam (a rural town east of Perth):

> ...there are parts of Australia now where it's all gone to desert...and parts of my brother's farm in Northam, oh golly, it was pitiful...I went up there...year before last, and I could not believe my eyes, all the trees were dying and all the sheep looked poor and it's dreadful, up there on the farms...so that's why it's such a serious situation not having the water".

Claire spoke very early in the interview about noticing the decline in water levels:

> I know the Gnangara aquifer seems to be just about empty because when we first came, Gnangara Lake had water in it and you used to surf cat on it...just about all year

> round...it must [the groundwater] just drop down more and more every year, it must do, it cannot be replenished at the rate it's being used.

She was also aware of a number of other lakes and wetlands which she felt had declined over the years, those she mentioned included Light Street Reserve Dianella, and the lakes around Joondalup and Kingsley. When specifically asked on its current state, she replied:

> I think it's terrible...in terms of the long term, that lake just to me just reflects everything that I would think is going wrong underneath the surface, it's just a really visible sign of it...

Some participants did not perceive the groundwater resources were being greatly affected by a decline in quantity. Bill was one who did not really perceive there to be a problem. He first implied this when asked what he knew of Perth groundwater resources, where part of his response was that "*there seems to be a lot*", but that he knew very little:

> ...it's pretty hard for a layman to say anything about that because I mean you go around and you see sprinklers on all over the different paths and everywhere else

When I asked Bill to confirm whether he felt there was a decline or not, he replied simply with "*well not really*".

Susan also did not think that Perth has an issue with its groundwater resources, saying that every year their cellar floods with about 6-8 inches of water, and has done so since they moved in. She was often "*surprised*" that they make "*such a big thing about water*" as she feels Perth has plenty of water and that there has been no decline, at least in Morley. She had also spoken about her father's work as a building contractor; he had told her that before they could build a number of buildings on St Georges Terrace in the city, they had to "*pump out lots and lots of water...I mean, we're on top of water*".

As the conversation went on, Susan explained how the trouble with groundwater was more of a localised issue, as she noted that friends in Wembley had to drill their bore deeper as the level had gone down over the years. She also felt that using water cautiously may not help these places:

> I reckon it's localized, I think water is localized like everything, if you're lucky enough to have it, you know...But I don't think it's [using water cautiously] going to help those areas because I think that's just basically it, what they're sitting on....

Susan did later mention that she felt we are "*definitely lacking a bit of water*" because she had heard of the caves drying up in the south of the state, but specified "*again I think it's areas*" reiterating her thoughts on localised water resources and water issues.

Like Susan, Melissa said she didn't think there had been any issues of groundwater decline, at least on a local scale, although admitting that it was something she hadn't really ever thought about. She did however remember hearing something about getting water from the South West:

> ...I think that they were trying to find water from another mound somewhere else and I think it was from the south-west...they were trying to get the water from the southwest to supplement the Perth water, and people down in the south west didn't want to do that.

From this statement it could be presumed that she has acknowledged that perhaps there is a decline in Perth's water situation, however, as it has not directly affected her, she has been somewhat oblivious to it.

3.3.3 Perceptions of Influencing Factors.

The common factors participants had claimed to be influencing (or could influence) groundwater decline included the market gardeners and irrigators potentially overusing groundwater and the decline in rainfall over recent decades.

When Joe was asked whether he felt groundwater users had any effects on the resource he responded with "*not if they use it the way I use it...using it just when I need to and nothing more, I've never wasted water*". Joe felt that the market gardens, and similar ventures, are overusing the water more so:

> Up into the market gardens and things like that, they're overusing it up there, but I don't think that we here in the metro area, down in suburbia itself, but definitely there would be some people who would abuse it".

Susan did not feel as though domestic users were having any great impact on the groundwater, as made apparent in her earlier comments on how water used on the garden goes back to groundwater (see section 3.2.3).

For Claire, domestic users are influential:

> ...It must just drop down more and more every year [the groundwater], it must, it has to, it can not be replenished at the rate it's being used because sometimes the streets are just about flooded [from people's garden reticulation]...
>
> ...I really think, that in general, market gardeners are maybe not the only ones contributing towards the problem, but I know other people, people have the expectations of being able to have lush green gardens...if they perceive they are not paying for it, it doesn't seem to matter to them.

Bob made the comment that "*the powers that be, the Water Board*" speak of the water table declining "*because everyone's got a bore these days*". After he had mentioned that "*three quarters of the houses in his street would have a bore*", I asked if he felt their use influenced the groundwater, to which he replied "*It's got to be, you know, you turn the tap on, it empties doesn't it...*". Bob further referred to both rainfall decline and the market gardeners as factors that have influenced the declining groundwater:

> You take the market gardeners for instance, just north of here, they have like those strawberry farms for example, now they've got acres and acres of strawberries and they've got the reticulation on there, and it just flows, when they want to water it they do and whether they need to water it as much I don't know, that's for you people to find out.

Tom felt that the water table was influenced by "*the amount of water being pumped out from it*" but also noted that there are less bores around the place as he was aware of a number of bore 'fill-ins' within his street. Tom felt also that market gardeners, and the "*Water Board*" were contributing to the decline by not using water sustainably (at the rate at which it is replaced):

> ...the Water Board and the surrounding districts of vegetable farmers and so forth, are drawing a heck of a lot of water from that area, from that mound, and it's not being replaced, I don't think...

John also referred to the market gardens contributing to the decline of Lake Gnangara, "*I mean, you see the market gardens and they're really hoeing into it, they get a tremendous amount of water*". Climate change affected groundwater as he felt our weather patterns have changed: altered or missed rainfall events. John explained "*man*" has caused the climate change by clearing vast areas of trees and vegetation across the

south-west (in relation to changing weather patterns and less oxygen produced), later adding:

> ...climate change is definitely affecting it [groundwater], if you can call it climate change, or whether you should call it the butchery of the forest, whichever way you look at it.

Later adding: "*whether it's the amount of water that's being used or the climate change, I mean everybody's talking about climate change*":

> There's so much being used that, I mean, the water tables going down, you can see it in, you know, the caves at Yanchep for a start, even the caves down Margaret River, there's a bit in the paper today, about the cave in Margaret River...the Lake Cave...the table's goue down because of the lack of rainfall down there.

Climate change was also significant for James "*it's not a good picture, it's a very bleak picture...they say our droughts are going to get much, much more severe, that's what they're saying on the television*". He spoke of how people are a little blasé about the effects of climate change:

> ...but it's important, you know, the trouble is that stuff takes place over such a long period of time, you don't actually see it...it's not like something that suddenly happens, you know, it's something that's very, it's like getting older, you don't really notice it day by day, but year by year you do and by the time you actually notice it. It may be too late you know.

I asked James to clarify how he feels climate change will influence the groundwater resources:

> It's obvious that the groundwater resources are going to diminish, we are going to get less, you know, it's going to put more pressure, we've already seen that haven't we, the fact that they are saying 'hey you are only allowed your bore twice a week now, same as ours, whereas a few years ago you were allowed to just turn your bore on for as long as you like...

Susan referred to the lack of rain influencing groundwater levels in her comments on groundwater use over scheme water use:

> Well if they go to scheme water [bore users], we haven't got any have we, we've got a problem with our water, our scheme water, because, you know, we don't get the rains and the rivers are drying up

A number of participants also referred to seasonal influences on groundwater levels. Joe had noted the differences in rainfall and seasonal variations:

> Oh well, you see, it will change seasonally, if you had a very heavy wet season to replenish all your underground water and things like that

John also had noticed seasonal declines in groundwater, claiming that his pressure gauge is always reading at a lower pressure nearer the end of summer. Bill had also noticed seasonal variations:

> I notice sometimes through the winter the water table rises and in the summer time it does go down, but it never reaches the stage where there's no water, there's always water there.

He later added: *"in the winter times if it's a very heavy winter, it will, the water, you can see it in the bottom of the liner"*.

Tom mentioned that his bore had gone dry once before during a real dry year and also admitted to not noticing a great deal of seasonal variations of late, adding that *"year's back yes, but recently no, it doesn't seem to have any effect on it"*.

Bob also had never really noticed any seasonal changes, instead highlighting that it's because he *"[doesn't] really use it [the bore] that much"*. In relation to rainfall influences on groundwater, Bob mentioned: *"weather... whether it rains or whether it doesn't"*.

Melissa also felt that, although she did not really feel that Morley had a problem and that she had not noticed any seasonal variations, that there are a number of factors that are causing the groundwater to decline, including rainfall, and also increased bore use:

> I guess we know that we haven't had enough rain to replenish the groundwater...and they're also talking about... there's too many bores taking water away...[groundwater] can drop if there's not enough rain...in which case there would be...trees dying you know, and things like that so that's got environmental concerns as well...

Claire, unlike neighbour Melissa, has noticed seasonal variations and spoke of them unprompted:

> We do find towards the end of each season that the water gets less and the water begins to smell, so I presume that even though it has been there for a very long time and that the level of people pulling it out brings it down, brings the level down each year and that it is replenished in some way over the winter so there is some feed from the actual water that falls...

Judith felt that rainfall and wind (evaporation) can influence groundwater levels, but focused more on the increasing population of Perth:

> Oh yes, I think it is because of the growth of population isn't it, you know, there's so many more people than there used to be and as I said they're coming from different parts of the world where water conservation isn't essential...[4]

Judith perceived interannular changes: *"...over the last 3 or 4 years, you know, we haven't had the rain"* adding that the last time she had the bore serviced, about 2 years ago, it was down to bedrock *"and the water that came up was dredged from way down and it was all stained and it was really dirty"*.

3.3.4 Perceptions of Groundwater Decline Consequences.

It had been considered by a number of participants that the first consequence of decline would be that it would affect the use of their bores, with many sharing similar thoughts to Bill who mentioned "not getting the pressure of water" if groundwater was to decline (similar to thoughts of Joe, Bob, John). Others (Tom, Susan) made comments relating to the sacrificing of gardens to paving or alternative cover as water would become a limiting factor in garden maintenance, with Susan sharing similar thoughts to Tom who had said:

> ...the gardens and lawns are gonna go and we will go more and more for native plants and maybe more for paving.

Most participants had to be further prompted to consider environmental consequences of a decline in groundwater. To this there was a variety of answers based around impacts to wetlands (decline and disappearance), loss of, or impacts to, plant and animal

[4] This also came up in a pilot interview undertaken with a lady who had emigrated from Englaud in the early 90's. During the interview she had mentioned, "back home they never really had to worry about conserving water".

species, limitations on population growth, increased salinity risk and concentration of pollutants in groundwater (less dilution) and perhaps having to pay more for water. In reference to wetlands, James had further said "*well they might disappear too, it would have a whole flow on thing wouldn't it, it would flow on to all sorts of things I guess*". Judith was one who had made the comment on lakes in the area drying up and the "cockatoos" no longer visiting.

Susan's comments in relation to salinity were:

> ...You will have a lot of problems...if it dries up underneath us, because as I say, we need things to be moist, otherwise...that's when you get the salinity, because everything's going to become salty because there's nothing there

Two participants could not further comment on the environment, with Bob sharing a similar view to Bill, who had said: "I can't really answer that because it doesn't appear to have affected here, so I wouldn't really know".

3.3.5 SUMMARY.

The data here showed that the majority of participants felt there was some degree of groundwater decline occurring across Perth. Influencing factors were considered to be a decline in rainfall and groundwater overuse, with particular reference being made to market gardeners. A number of participants also mentioned the influences of seasonal variations in rainfall on groundwater levels. In relation to the consequences of decline, a number of participants had mentioned how their bores would no longer get the same pressure of water, or perhaps wouldn't get water at all. Most participants had to be prompted for their thoughts on what environmental consequences may arise from a lowering groundwater table, to this a number had mentioned loss of or declines in wetlands as well as flow on effects to plant and animal species.

3.4 PERCEPTIONS OF GROUNDWATER MANAGEMENT.

This sectiou will explore the degree of awareness as to who is responsible for the management of groundwater resources and who should make the decisions regarding an individual's use of their bore.

3.4.1 Awareness of Managing Body.

When participants were asked who they thought were responsible for the management of groundwater around Perth, the responses ranged from "*I don't know who manages the groundwater*" (Claire), the "*Water Authority*" (John, Tom Bill) the "*Water Corporation*" (Joe, Susan) the "*Water Supply Department*" (Bob, Judith) the "*Metropolitan Water Supply*" (James) with one (Melissa) saying "*ah Water and Resources...*", when asked if it was a Government Department she was thinking about her response was "*Yeah, ah the Department of Water...Resources?*".

3.4.2 Decision Making – Perceptions of Whose Role it Should Be.

There were differing opinions as to who should make the decisions on how domestic bore users use their bores. The majority felt that ultimately it's the managing authority who should make the decision, while the remaining four felt that the decision should be theirs – although their reasons for this differ widely from being 'educated' on, and responsible for one's own, water use, to liking to be able decide when the garden needs water.

3.4.2.1 Decision Making by Authority.

When Joe was asked he responded by saying "*Well, the guidelines are set down and the individual is to follow the guidelines*". Thus implying that the individual can make the decisions only within the guidelines set by the managing body, the guidelines in this case, as Joe also referred to, are the bore water restrictions now in place for domestic users.

Bob's response was similar "*Well that Department [Water Supply Department], because they are supposed to have their thumb, or their finger on the pulse*". This may be interpreted to mean that those who manage the overall system should make the decisions as to how people use their bores. John also felt that the government should make the decisions as to when and how bore users can operate their bores, saying "*the Government will have to, I mean the Water Authority would have to*".

The 'authority' setting the boundaries for users to remain within was Susan's response:

> Well I think it should be, well, controlled by the council or Water Corp, whoever they want to, it doesn't really bother me who controls it but I think it should be lenient, you shouldn't have to be, that they are going to say 'oh you can't use your bore anymore' because I think that would make things hard on people...and people will start using scheme water..., and then we've got a problem.

Claire also felt that it was the Government who should make the decisions on how and when bores can be used:

> Well again I think that it's the Government that has to, I don't think it's something that we can just be allowed to use because we will abuse it and it isn't as if you can recoup it, you can't fix it...

Bill had initially said "*me*" then added that "*if the person of authority is talking about saying we could have it 3 days a week, well I'd be happy about that*". Keeping in mind however that it was unsure as to whether he was aware of the groundwater use restrictions (see section 3.4.6: Restrictions), it could still be taken to mean that Bill thinks a majority of the decision making (in reference to rostered days) would lie with the '*person of authority*' to make the allowances.

3.4.2.2 Decision Making by Bore Owner.

Of those who felt the decision should lie with them as to how their bore is used, there were differing reasons. James and Judith felt the decision should be theirs because of owner responsibilities or because they saw themselves capable of efficiently using water. Melissa felt the decision should lie with her so that she can water when it best suits her and her garden, Tom advocated that as he pays for it (installation and power) he should decide how it's used. Tom also noted however that people should not be permitted to use it all the time every day.

James felt that the decision should be his, for reasons of responsibility on the bore owners' behalf:

> Yeah I should, you know, and ... the Landlord of course...yeah it's each house owners responsibility to make sure they don't water their garden too much, or too little you know...that's the main thing for me, is for people to take responsibility, and be a bit careful, not just for water, with everything.

Judith also thought the decision should be hers to make, seeing as she felt she was an educated and sensible person capable of using water conservatively:

> Well I think in my case, I should...as long as I'm educated and sensible and, you know, I am educated and sensible, I have a University Degree...I think that for the people who use their screw, they, I don't know how you would manage this, I guess that you would have to penalise those less educated wouldn't you, they're already penalised from the lack of education you know, but I guess education is the thing...educate them how to use their bore and not to abuse the privilege of having a bore.

Melissa brought up her views on decision making whilst on the topic of the water restrictions where her response was "*I like to decide myself when to water*" because then she can water when the garden needs it rather than on a pre-determined day (see Section 3.4.6: Restrictions):

> I think so, although I don't know how that sort of reconciles with the fact that the water belongs to everybody, which, I'm not sure how that works out...so I guess yeah I like to be the one deciding, on the other hand there are still people that would water every night with their bore, and I don't like that either, but I guess they're deciding for themselves as well...

Tom felt that to a certain extent the bore owner should decide, but be constrained:

> ...to some extent it's up to the person that put the bore in, I mean that person has gone ahead and paid to have the bore put in ...they are paying for the cost of running the bore, so they should have some say in the use and the operation of that bore, but then again, you know, they shouldn't be allowed to just go ahead and turn it on 7 hours a day, or 7 days a week, whenever they feel like it.

3.4.5 Perceptions of Individual Resource Ownership.

There was a mix of responses and a mix of reasoning as to why or why not the participants felt they had ownership over their groundwater. A couple of participants did feel as though they had ownership, while others felt perhaps that Government owned it (or both people and Government), with others feeling that it was something for everybody with responsibility rather than ownership being the concern.

3.4.5.1 PROPERTY OWNER HAS OWNERSHIP.

Bill and Susan felt they had a degree of ownership over their groundwater. When Bill was asked *"yeah I think I do"* adding *"I mean I pay my taxes still, like everyone else, even though I've been retired for a few years, I still pay my fair share of income tax"*. For Bill, an entitlement to a share of the groundwater comes through contributions to society.

Susan felt that although she may not have ownership, she feels as though she should:

> Well again, as I say, the property belongs to you, to the people, so it should be theirs, whatever's on the land should be theirs. But I know it's not like that, that's why it's a farce that, you know, people say 'oh you own your property'; you own your property up to a point.

For further clarification I asked if she felt she had a degree of ownership over the groundwater:

> Well it should be, I think so, but I don't know what the Government thinks...because the property is mine, you know, we purchased it, we paid for it, we found the water, we put the bore down, we have a few reasons to say that it belongs to us...but at the same time I know that Government will probably say 'no everything on the property belongs to us', but we pay taxes, we pay rates and taxes so I suppose if they want to put another tax onto it, it's only going to cause another lot of big inflation, I mean it's a never ending saga, all these taxes and all these things only push wages up.

3.4.5.2 GOVERNMENT HAS OWNERSHIP.

Bob did not feel any personal ownership but felt that it was the *'Water Board'* who had the ownership of the groundwater:

> Let's say the people that own the houses over the top of it, they own it, but because that's not actually true, it belongs to the, I'd say the Water Board, so they let us use it by putting reticulation down...so it's there to use, so I didn't have to use tap water or anything like that.

When further asked who he felt then had the right to use groundwater, he responded with "everyone...well everyone that can sink a bore, some people think it's a right to waste it, but that's because they're a bit screw loose, they don't care".

Judith's (P7) response was "*well I suppose it's the Governments resource isn't it*" and "*...I really think it's a communal thing*". Judith's response could be taken to imply that while the Government has the 'ownership' of the resource, everybody (who can access it) has the right to use it.

Claire was one who felt it was more a responsibility thing than a matter of ownership:

> They [property owners] have a degree of responsibility, I don't know if they have a degree of ownership...I suppose you could take that to court like the mineral rights or whatever, that maybe we have got it [ownership], I mean we only have a degree of ownership as far as we have a degree of ownership of the water in the sea that we can use without abusing it...

When asked then who she felt had the right to use the groundwater:

> Well I suppose that I would have to say the Government would have to have the rights to it because we've got it... that would be the only democratic way for it, it's just that sometimes, sometimes people don't understand the things for their own good in the long run and so yeah, I would have to say it's a Government responsibility to make those decisions.

3.4.5.3 COMMUNITY OWNERSHIP.

Joe's response to this question was "*well as far as I'm concerned, I own the bore and the bore is into a tappable situation for anybody that wants to tap into it*". It could be taken that perhaps Joe feels his ownership extends only as far as the bore itself and does not extend to the water as others can access it too. When asked then if he meant that everybody has a right to use it, his response was "*well the person on top of it should have the right*" further adding "*so long as they use it sensibly and don't just waste it*".

When John was asked who he thought owned the water, his response was "*whoever uses it*". To clarify I asked if he felt he had a degree of ownership:

> Not really, because according to law, I mean even if it was gold, if I found gold down there I'd have no claim on it, I'd have to actually put in a claim, you only own a certain depth of your land and it's not very deep...so you don't actually own the water no...

This question had followed after conversation about John's views to fees and charges being applied to bores (which he didn't approve) and in the conversation he added "*So if they wanted to charge you for it, the Government would have to prove it's theirs*". Who has the rights then to use the groundwater? He answered "*well, I should say anyone who can actually use it*", a similar response to that given by the previous two participants.

Tom expressed this conundrum: "*The country owns the water, the people in the, you know, everybody owns it, nobody has ownership of it*"

> Well it's simple, it comes from the sky and it drops down and just because the water courses lead to various areas, that doesn't mean to say that they should have ownership of it, I mean, it's for everybody.

Melissa (P9) also felt "*it's a resource that belongs to everybody*"... "*I guess because, in the diagram I've got it as a moving stream, so that makes it belong to everybody*".

James was similar; he did not feel individual people had a degree of ownership, but felt it was more a degree of responsibility. When asked how he felt about groundwater ownership and why he responded:

> Well it's not really ours is it, it's certainly not ours, no it's not ours, we are just using the stuff that's here, the water that's here...I just think because it's like, part of the planet, you know, it's just a part of the planet and I guess you're right in a sense it is ours, you know, in a sense it does belong to us and we should, well it's a responsibility thing really.

3.4.6 Perceptions of Groundwater Restrictions.

This section has been divided into three, those *in favour of* water restrictions, those who are in the unsure, or ambivalent, and those who did not much like the restrictions at all (against). Five participants were somewhat *in favour of* the water restrictions (Joe, Bob, Tom, James and Claire), four were a little unsure (John, Bill, Susan and Judith) and one had little support for the restrictions (Melissa).

3.4.6.1 In Support of Restrictions.

Participants considered here were those participants who had stated the restrictions were good, fair or reasonable, and that expressed no issue with abiding by the rostered days and times.

Joe, during discussion about his bore and its use, unprompted, mentioned how he "*religiously stick[s] to the watering days as rostered*". When later asked what he thought of the restrictions, said: "*Well I just stuck to them because I thought they were reasonable when they first brought in the watering days, so I just stuck to them with my bore*". When asked if it changed how he used it he said "*only slightly, I do it now on specific days rather than when I thought it needed it, sometimes not even that much...*" He admitted also, however, that he was not much of a gardener, with relatively minimal gardens, so he didn't appear to have much of a problem in restricting his use.

Bob was also aware of the water restrictions on bore usage and was another to raise the topic unprompted. While discussing what he knew of groundwater around Perth, surmised that if the "*Water Board*" is setting restrictions then the groundwater must be declining, adding "*but I follow the instructions of what the people want, you know, 2 or 3 times a week*". He stated that restrictions hadn't worried him and that he does a lot of water "*bucketing*" if plants require watering on a non-rostered day. He felt the reasonableness of the restrictions "*depends on what you're growing, and what needs what, so you adjust the water supply to suit the plants you have put on*".

Tom had no trouble sticking to the days:

> I thought they were very reasonable...I have no difficulty what so ever regulating it, I'm quite happy to go along with their normal restrictions for the mains pressure supplies, as I say, I've got a power board down there with a control timer on it and I can control it to come on the days of the week that are allocated.

For James the restrictions were a good idea:

> I think they are very good because if people can't get their act together...well it's like the road rules isn't it, why don't you not have any rules on the road, because more people would be killed, I guess, same with the water, bring in the rules and if they can't

get their act together then it forces them to do it, and fine them if they don't, that's fair enough.

He added however that he had been disappointed that he had not received "*something in black and white*" that stated the rostered bore use days.

Similarly Claire strongly supported the water restrictions:

> Well, from the day the other restrictions, we've always thought about the water as being as precious as the water which comes out of the tap really, and never understood...that people would think that it was unlimited, especially when you can smell very quickly that you've gone below the level, you can get the smell...the smell of sulphur. So I just appreciate that we've got it but I don't actually take it for granted...still, most of them don't understand still that there are restrictions on the bore, I don't think the Water Corporation had made it in anyway clear, even this year on the newspaper ads, that it now applied to bores as well, I think it was very ambiguous, the advertising, and unless you actually knew it did, you...well because when I would say about the days, they say 'no it doesn't apply to us'...

Claire said that she had been '*upset*' that advertising in the past year had not made it clear that restrictions now applied to bores, she felt that perhaps those with bores were not reading the advertisements for water restrictions because they did not feel as though it applied to them, she had felt this because:

> There's a lot of people in this street that would absolutely definitely not be having their water on, on the wrong day if they knew they were doing the wrong thing.

Claire regarded the groundwater to be, in a sense, more precious than the scheme water: "*I mean, we can use the desalination plant for that sort of water if we really wanted to, but we can't replace groundwater*". She also referred to the use of automatic timers in control of bore reticulation saying that many people may not be watering when they should because of the difficulty in setting and re-setting the timers:

> Those settings are difficult to set in the first place, those automatic things, once they're set people don't go back and change things, and once the days of the week were set on those obscure days that you get no body in their right mind is willingly going to go back and fiddle with it...I think with a meter on it, it would be better.

3.4.6.2 AMBIVALENT.

Some participants had more or less agreed with the restrictions but had an issue with some aspect of them, such as the rostered days, setting reticulation timers or a lower perception of the issues in our groundwater resources.

Reflecting Clare's comments, John agreed that the restrictions were reasonable however stated that due to the nature of his reticulation timer, he had trouble setting it to the rostered days:

> I used to water every second day…which I cant do now...it's a bit difficult because my clock works on a 14 day timer…it's very hard to water the way they wanted us to, so in the finish of it, I've just set it for the days and that's it.

Judith, after discussing her issues (below) regarding the groundwater restrictions, added that, on the whole, she did support them:

> I think the restrictions had to occur because without them the water restrictions, there are people that would have just used up the whole lot…

Her issues in relation the restrictions stemmed from her being confined to a wheelchair, which impeded her movement around the garden with a hose (which is not a restricted use):

> I don't think they [the restrictions] should apply to disabled people that can't go around with a hose…I therefore think that I should be able to put my bore on and water my garden whenever it's applicable. I don't mean over 24 hours of the day, I don't mind doing it in the early morning and late in the evening not at all.

Susan mentioned the bore water restrictions unprompted: "I agree that maybe councils could say, like they do, 3 times a week". She spoke of how she did not see a problem with Perth's groundwater resources, particularly not in her neighbourhood, and therefore was not overly supportive of the restrictions:

> First of all I thought 'Oh?', you know, because I really don't think that Perth, you know, because…there's a lot of water underneath it, I really don't think we have a problem.

She had mentioned earlier in the interview that she had "*always watered [the garden] 2 or 3 times a week*" and was not one to water all the time, adding:

> I don't think it's necessary that you water all the time. But if it's a hot day, you know, like in a very hot week I might water every day, but then if we have cooler weeks I only put it on 3 times, 2 times a week.

The comment she made about watering the garden everyday would be a breach of the conditions of bore use. It appears as though she feels she offsets her extra days used in summer, with days of no use in winter.

From the answer given by Bill, it is unclear whether he had known about them or not: " *If they were to set it at 3 days a week, that wouldn't worry me...you could give it plenty of water in 3 days a week, some people don't even bother watering at all*". He later added, on the topic if decision making regarding bore use, Bill had commented that "if" three days a week was set, he would not have an issue. The ambivalence here centres on whether or not Bill knew that restrictions were in force.

3.4.6.3 Little Support for Restrictions.

Melissa raised the matter of restrictions when asked if she had any issues with the way groundwater was used or managed around Perth. She had responded that she likes to decide when her garden gets watered:

> I know that bore users, that you've got certain days that you can use your bores now...I guess I like to be more individual ...I like using it three times a week but I like to decide when to use it...because you might have had just a drop of rain on the day you should have been using it and you think 'oh ok the garden doesn't really need it', but if I don't water today it's not going to get watered for another 3 days, so I'd like to tailor that myself.

When asked if she thought the restrictions, on the whole, were a good idea, and whether Melissa thought they were working, she commented that people may simply ignore them, which she puts down to the value (money and time spent) people placed on their gardening:

> I'm not sure, I don't really want to say most people ignore it because I'm not sure...I haven't seen in the other suburbs but I know around here it sort of depends how much stock people put on their gardens. They know that if they're not putting a lot of work and a lot of money into their garden, they know that

> they can afford to water just 2 or 3 times a week, whereas the ones that have put a lot of money in their garden feel they're entitled to water it.

This again raises the value of a garden as being an influence behind an individual's groundwater use on the garden. Those who value the garden more, or the pleasure of gardening, are more likely to use more water than others who place less value in their garden, either recreationally or as a means of improving property re-sale values.

3.4.7 Perceptions of Groundwater Pricing.

There were mixed responses to whether or not the participants would accept paying a fee or charges to use their bore. When asked how they would feel paying for it, five participants (Bob, John, Bill, Judith, Susan), had stated they would not be keen to pay and Susan added that it might be a good idea for new bore owners, but the older bores should not have fees attached. Three participants (Tom, James, Claire) said they wouldn't mind a fee, with Claire in particular feeling it would be a good idea - and the topic did not come up during the interviews with Joe and Melissa.

3.4.7.1 Against Fees and Charges.

Bob responded to the question of paying a fee in saying that, as a pensioner, he probably couldn't afford much more:

> Seeing as I'm a pensioner they should let me off...it's just another way of de-plenty-ing my pocket money...it doesn't matter what you do now, petrol's gone up, foods gone up, their going to start charging me more for water. I've just paid the water bill and that was $388 or something, I don't use that much.

John was also not keen on the idea of having a charge attached to the use of their bore saying outright that "I wouldn't like it" and he continued in saying that it would be difficult and expensive to manage in relation to any kind of metering:

> I think it would be difficult for them (the government) to do that, seeing as they're the ones who have been, at one stage, telling people to put bores in and now that they've fallen in the poo themselves to suddenly start charging you for it, would be a bit hard, and of course it would be very expensive to meter all the bores, not only to meter them but then you've got to follow up on it... you've

got to have someone to go and read the meters, so...I don't think it's necessary myself.

He added that perhaps a bit of education would help in getting people to use water more wisely:

> I think with a bit of education and the fact that they've now put people with bores on notice that they can only use them certain days, it's as good as anything as far as I'm concerned, as long as people stick to them.

John added later, while talking about the amount of water that industry uses over households: *"[we're] in a boom right now, [we should] make the blighters pay!"*

Bill said, he felt that he was already paying enough:

> Well, I would think it stinks...I mean we pay enough taxes now for everything ... you've got to pay GST on it...and I reckon we are paying enough.

For Judith more fees were something she could not afford:

> Oh I wouldn't like that at all because I probably can't afford it...with a pension I couldn't afford anymore expenses, I mean, that would just be more than I could bear.

Susan was somewhat in the middle, having divided views as to whether or not a fee should be attached to bore use, her comment being:

> I don't really think it's very fair because number one, I think it should be for the people putting new bores down, they should pay... you should have to apply to put a bore down, and if people applied to put a bore down then they should be charged a tax...but people that have already got a bore down, I don't think it would be very fair for them to have to pay a tax.

This notion could raise a number of issues relating to equity, although Susan doesn't think it's fair that she should pay a tax, it may also not be fair for those people putting in new bores to pay now, while for so long, so many others were not paid for. Then again, industry and agricultural groundwater use licences had been free in Western Australia up until around mid 2007 when the Department of Water introduced annual administration and bore licensing fees (DOW, 2007).

3.4.7.2 In Support or Acceptance of Fees and Charges.

Of those who liked, or would accept, the idea, Tom felt that he would not be worried so long as the charges were reasonable:

> Well if it was reasonable I would not be too worried, but it depends on, you know, what they want to charge for it".

James had also said he would not be overly phased, saying "*oh well, it's fair enough...I wouldn't have any concerns with that*". He followed that in saying that the landlord would be the one who paid it *"but if I was the landlord and I did own the place I would pay it, it's a water resource you know..."*. Later in the conversation, when talking on the decision making process in domestic bore use, James had noted what he thought was a lack of the knowledge to use bores properly at efficient rates. He thought that perhaps with metering at least then people would know how much they are using:

> The important thing for me is people getting their sprinklers right you know?... I guess if they are getting charged for their bore at least they would have an idea of how much water they are using...once they realise how much they are using, you know, because you get your allowance and your excess and all the rest of it, that would be a good thing I would think.

When asked whether this meant meters should be attached, and if so, how would he feel paying for a meter to be installed, James responded, "*well I guess I wouldn't be overly wrapped about it... I would probably just pay it and, if it has to happen it has to happen you know?"* He added:

> Older people and that that are struggling would find it difficult you know...especially when more than half their money would go on rent of course, it's a terrible situation...but then again, I guess the proportion of the people with bores who are pensioners might be small anyway.

Claire brought up the topic of having a fee attached to using a bore numerous times during the interview. One of her first comments was that "*...if they [groundwater users] perceive they are not paying for it, it doesn't seem to matter to them...*". In further conversation about management issues Claire mentioned the notion of applying fees again and felt that perhaps it would be necessary to licence bores used for industry and agriculture (which already happens), in adding that "*maybe [having] a premium on the*

bores" might help the situation. When I went to ask that if a charge were to be attached, she jumped in before the question had finished saying:

> Just about without any doubt in my mind, without any doubt in my mind the way to get people to think about things is to make them pay for it...because that was the catch phrase 17 years ago when we came here was 'well it's free, why would you not use it?'... the hip pocket is where you, I really think we need to do it... and meters on them you know, or even if you licence them it will at least make people think about it a little more.

Later in conversation on the subject of how groundwater management could be made more effective, Claire made the comment that "... *I don't particularly want to pay for it myself but I still think that's the only way if you're asking me how to be effective, I think it will have to be money*". Like James, Claire thought a fee on bores may help make people more aware of their use, but both are slightly hesitant towards their own willingness to pay.

3.4.8 Views and Issues towards Groundwater Use and Management.

Issues relating to the use and management of groundwater resources were prevalent in many interviews from a number of different perspectives. In many cases, comments referring to this theme recurred during the interviews. However, there was also a question that asked for participant's thoughts on how adequately they think the resource is being managed. Any discussions on regulations and restrictions, and the participant's perceptions to those, have been covered in an earlier section and so will not be included within this section.

The management issues included the 'overuse' by market gardeners, Council park irrigation systems, and other alternatives not being made more readily available. A number of participants had referred to the use of the Ord River to supplement Perth's supplies, with those having mentioned it (4/10) half were in support (Bob, Susan) with the other two not too keen on the idea because of costs involved (John) and the damage it may cause to the flow of the Ord River (Joe).

When Joe was asked for his thoughts on the management or use of the groundwater resource, he responded:

> Well, as with anything like that, when you get open slather there will be some that will abuse the privilege, that's for sure, and there will be plenty of them, you don't have to go very far to see it...up into the market gardens and things like that, their overusing it up there, but I don't think we are here in the metro area, down in suburbia itself, but definitely there would be some people who would abuse it...you know, the ones that water everyday...

This overuse concerns Joe:

> ...well they must be over-utilising them somehow because they are always looking for new supplies because they are overusing the ones they've got, so I think that answers your question doesn't it...by allowing the people, I mean there's all these developers going in and the first thing they do is put in reticulation in the new house and therein lies part of the problem I believe.

As noted in section on Perceived Conditions (Section 3.3.2) John feels that they *"[the market gardeners] are really hoeing into it"*. John also mentioned extensive tree felling in the southwest that has contributed to local climate change and changes in weather patterns. These comments are relevant for inclusion in the use and management of water resources as it was an issue he feels needs better management because it influences groundwater resources via rainfall decline. John further added how he feels climate change, or *'butchery of the forests'* as he also referred to it, is affecting our water resources.

John had expressed how we how we perhaps are not as bad as other states:

> We're not in dire straits like some other states, I mean some states are really in dire straits, I mean some country towns, actually some of our country towns like Lake Grace...at one stage....was bringing water in tankers.

He also expressed concerns in how he feels that Wellington dam has been somewhat of a missed opportunity:

> ...I think they've missed out a lot on, is Wellington Dam, which is saline now...so you've got a great big dam that overflows ever year, still, virtually useless

Later, towards the end of the interview, John also made the comment that most of the water resources are used by industry over people (domestic purposes):

> I can't remember the percentage [on what domestic premises use] but it's, I believe it's 14 or 15%, the rest of it is used by Industry, and a lot of that is not

paid for, I mean if they, you're in a boom at the moment, make the blighters pay for it.

He added that this money could be used to fund more desalination plants, although he does not feel the desalination plant in Kwinana is doing much good for the local environment.

For Tom, the matter of the lakes declining (see section 3.3.2) could be attributed to two specific user groups:

> ..the Water Board and the surrounding districts of vegetable gardeners and so forth are drawing a heck of a lot of water from that area, from that Mound (Gnangara Mound), and it's not being replaced, I don't think.

Later in the interview when asked how he felt the managing body (in his case the "*Water Board*") are going at managing the resource:

> In some extent they could be doing better with it, because you look at some of the places, where the market gardens are, at times I feel some of the water there's going to waste, because it's just being sprayed up in the air and it's evaporating at a very fast rate instead of being down and being reticulated from the ground

Bill mentioned the mismanagement of sprinklers being a concern of his on two occasions. First was when he was asked on what he thinks the current state of the groundwater resources are, which he thought were ok (see section 3.3.2), he added:

> It's pretty hard for a layman to say anything about that because I mean you go around and you see all the sprinklers going all over the different paths everywhere else.

A little later in the interview he made a similar comment when asked what he thought about the management of the groundwater resources:

> Gee that's a bit of a, that's a bit hard for a layman to say really isn't it, I mean sometimes you see things happening, you see sprinklers going and it's pouring down with rain, well you couldn't say that's being well managed could you?

For Bob, overuse was related to poor management of infrastructure:

> ...Especially the councils, they've got the electronic systems that turn it on all the time and it just runs and runs and runs and there's no one that goes and turns it off, you know, it's set to run for so long...and then of course you've got the Water Supply Department who have old pipes in the ground...

Bob mentioned two recent occurrences of "*faulty equipment*", such as burst water pipes around the city. He felt that huge amounts of water must have been wasted and that perhaps the "*Water Supply Board*" should do more routine maintenance and record keeping on pipe installation dates, "*Let's say give it a 20 year lifespan and you go back and inspect in and renew it if it's bad*".

Bob mentioned how it would cause a flow on effects if people were no longer allowed to use bore water: he mentioned reticulation installers/suppliers, lawnmower services and manufacturers "*they'll go broke, all because it hasn't rained*".

James had also commented on the mis-use of groundwater by councils:

> ....the Government departments too, they've been caught out a few times, you know, automatic sprinklers that turn on when it's already bloody pouring bloody rain...and the tax payers paying for it, it doesn't t go down too well..

Water conservation advertising was another issue for James:

> I personally think there should be more on the television...you very rarely sees any adds telling you to conserve water, occasionally you do right now...but that's not a groundwater thing is it?.

A common issue throughout Claire's interview was also in relation to the nature of the groundwater restriction advertising campaigns:

> I don't think that the Water Corporation made it (the bore restrictions) in anyway clear, even this year on the newspaper adds that it now applied to bores as well. I think it was very ambiguous, the advertising, and unless you actually knew it did, you, well, because when I would say about the days, they say 'no it dint apply to us, to a bore'

When asked for her thoughts on how the resource is being managed and used, she found it was managed "*really badly*" she said " *I do think it's disgraceful*" and returned the theme of how she feel the restrictions on bores should be and could be better advertised.

Judith did not have much to say on groundwater management, other than water should be conserved at all costs, swimming pools are a waste of water and fluoride should not be put into our water supply. The swimming pools came up early in the interview before the topic of resource management arose, she felt they used "...an enormous amount of water" and attributed them to another source of groundwater depletion.

Susan had felt that it was "*governments fault*" for a number of our environmental issues and feels that other things they are doing (allowing oil exploration and polluting activities, etc.) are more damaging and are bigger issues than what people are using to keep their "*properties nice*":

> I don't think the Government has done enough about saving water...they know the world is getting warmer...I really don't think it's human fault, I think it's Government fault. I think they are not protecting our world the way they should be protecting it...

Later in the interview, when the question relating to her thoughts on groundwater management and use around Perth was asked, Susan responded with:

> Well at the moment I don't think anybody's ever done much about it have they, I mean they've just started to realize that there's a commodity there, when we've been probably enjoying that commodity over many years, and I think they are only just starting to realize now...I think it's a bit late [their management], I think they should have realized this, or done something about it, you know, a long time ago, now if they are going to start bringing it out now, they are just going to end up ruining it for everyone.

She said people might let their gardens go, which she feels would be worse because she felt that that would inhibit the movement of water down to the groundwater:

> I think it looks much nicer and it's better for the environment if we have a garden rather than let everything go and become dry and pay because the water won't go down between the roads and people putting cement everywhere...water's not going to go down so then people are going to have a problem.

Susan further discussed how this dryness might bring about salinity and that the lack of trees would mean there would be less oxygen.

Melissa had concerns in relation to the bore water restrictions, saying that she would much rather like to decide when to water rather than have to stick to rostered days. This notion was explored at greater depth in the sections 3.4.1 and 3.4.6 on Decision Making and Restrictions

3.4.9 Management Recommendations.

During the latter parts of the interview participants were asked for their thoughts and recommendations on the approaches managing bodies could undertake to better manage our groundwater, or water resources in general. Again the use of the Ord River was widely discussed however it will not be addressed in any great depth other than it being

mentioned by a number of supporting (Bob, Susan) and non-supporting participants (Joe, John).

A number of other participants also mentioned alternative water sources that should be considered as means of reducing the pressure on groundwater, these included desalination (John) rainwater tanks (Bob, John, Susan, Melissa), grey-water systems (John), storm-water use (Susan, Melissa, and industrial water recycling (John).

Joe did not express any great concerns other than those already mentioned above: that water was being over-utilised, that market gardeners perhaps wasted water; pollution of groundwater through run-off; and issues with new land developers installing extensive reticulation systems.
Bob on the other hand had felt that perhaps the councils should set a better example, as understood by his comments on some people he thinks as being a little "*screw loose...especially the councils...they've got the electronic systems that turn on all the time*" and also comments on "*the Water Supply Department who have old pipes in the ground and every now and then you see millions and millions of water flowing down the street*".

John also recommended that the Government should be setting a better example: "*even on some Government properties you'll find the sprinklers running, they are still set and they will run everyday*".

Bill did not have many suggestions or recommendations other than management attention where sprinklers go all over paths and down streets, and on when it's already raining "*you couldn't say that was being well managed could you*".

In relation to how the groundwater resources could be conserved, John also spoke of making industry pay for the water they use "*...that would pay for a couple more desalination plants or something*". John said water smart living can be achieved, referring to the home of a garden show host "*he's almost self-sufficient on water...so it can be done*". While John could do this he said "*you'd miss your bore, the convenience factor is just not there, you know, you get lazy*". At a larger scale were his management recommendations related to climate change and the "*butchery of the forest*" as he referred to it as. John was one who strongly advocated education of groundwater users:

> ...I think with a bit of education and the fact that they've now put people on notice that they can only use them certain days, it's as good and anything as far as I'm concerned, as long as people stick to them...you've got to have an education and realize how much water you need...it's a matter of being logical...people will just have to be educated on what sort of equipment to use...there's a lot of education to be done...but whether people will accept education or not....

James had also mentioned education:

> First and foremost I think we need to educate people to be careful with their use of water and not just waste it and leave running taps and dripping taps and all the rest...I personally think there should be more on the television...maybe it could do with some adds that are tracking that, you know, towards groundwater, rather than just the tap water...maybe something in the water bills and stuff, you know, that would be a nice cheap way of doing it, cheaper than TV...

Claire's management recommendations, as highlighted in the section on bore water restrictions (section 3.4.6), were also related to education and awareness raising in relation to groundwater restrictions. She had felt that the introduction and enforcement of the water restrictions on bores should have been better handled, she felt it should have been made more clear in both TV and newspaper adverts as well as in other language as she felt that perhaps some people didn't understand the harm they were doing or didn't understand the restrictions. She suggested advertising "*in the language of the minorities*", whom she referred to as being long standing or common residents in some areas; and also suggested targeted management (in suburbs with high bore use).

Judith was another who felt that management through education could help improve the use and conservation of the resource. To do this she felt that best place to start this education is in school "*I think that's where good things start to happen*" adding there should be "*education at every level*" although noting that "*there is a type of person that you really can't educate...they don't appreciate it, you know, and therefore they don't think they're under the community pressure...*". She did not feel that television was the way to go as she wondered if people watch it like they used to:

> People don't watch television in the same way they used to...when television first came in they were glued to it, now their glued to their mobile phones and their i-pods and their different things, I mean technology has changed...I don't know whether TV advertising carries the same weight as it once did.

Susan also mentioned education as a means of getting people to do the right thing towards the environment:

> We should be educated a little more and I think it's a good idea that they are educating us on this...again for the ones that don't realize that the, you know, that the world is getting warmer...through education I suppose and through putting restrictions...they'll realise, and that I think is a good idea.

When asked if she could further explain how people could be educated:

> Oh just through the papers, through television...we get all our education through television, both good and bad...so maybe a good solid education from the television, just sensible things...most people understand and because we are educated today, makes it a lot easier for them to let us know what's going on...I think that's where their money should be spent, on educating people

Claire had also felt that attaching a fee to the use of bores would make people think more of their use, with the idea of attaching a fee being raised by her before any related question had arisen (see section 3.4.7: groundwater pricing). She also felt that metering would be a better way of managing domestic bores, as opposed to set days, because of the difficulties she notes people to have in having to set automatic timers to "*those obscure days*".

Tom mentioned a few recommendations for management when discussing his views on the current state of the groundwater resources:

> ...my opinion is that we should be recycling our sewerage water, instead of pumping it out into the ocean, pump it back down through the ground, once it's been through the system it's clean pure water, I can see no reason why they can't pump it back into the ground and allow it to filter back through the system and be reused.

When asked for his thoughts on how the resource is being managed at the moment, Tom felt that "*in some extent they could be doing better with it*" noting that he still sees water being wasted as some places, such as the markets gardens.

In light of this he was asked what could be done to improve the situation, he responded with:

> Well there's only one way to do it and that would be to regulate it with meters and that way if people are wasting it, they can be charged for it

It may be worth noting here that Tom had said that he would not be worried paying a fee himself "if it was reasonable" (see section 3.4.7: groundwater pricing).

Judith, in commenting on what could be done to improve the use and management of the groundwater, had stated "*we really have to save every drop, or pay for every drop*", although she was not keen on paying for it when considering her financial situation "*I probably couldn't afford it*".

Susan also mentioned how we shouldn't stop the use of groundwater because if more and more people put paving down, she felt that this would cause bigger problems as it would stop the water going down:

> If they are going to over build everywhere. You know, the water doesn't go back into the ground because the houses are covering the ground, of course you're going to have less water going down...

There was also a question that asked if participants would be willing to offer feedback, through something like a community forum, or if they would be interested in attending something about Perth's groundwater resources. Only James and Claire said they would have been interested attending, James saying so because those types of things interest him (environmental issues) and Claire because she would like to see "*something very concrete of what happens or where it goes or what's going to happen...I don't know, do people give it any thought at all about where it comes from?*.

3.4.10 Summary.

In relation to who it is that manages Perth's groundwater resources, most participants had referred to the Water Corporation (although their names for this Department varied) as being the authority responsible for managing the groundwater resources. One participant was not clear about this management authority, while one had suggested the Department of Water and Resources. It was also considered by the majority that this authority should also be the one responsible for making the decisions in relation to how residents can use their bores. A number of participants had felt it should be their

decision, with the reasons behind this varying from matters of education, sensibility and responsibility to being able to decide when the garden needs water.

Although most of the participants saw the groundwater resource as something that is not owned by an individual, with some using the words of it being 'communal' or something that should be 'shared', there were some that did feel they had a degree of ownership. These feelings of ownership stemmed from either that they pay their taxes, they paid for the bore or they own the property and therefore have a degree of ownership over the water they can abstract.

On the topic of groundwater restrictions, half the participants supported the restrictions, with the remainder mostly being ambivalent. On the topic of groundwater pricing and fees the majority of those who were asked this question did not agree having any fees or charges attached to the use of a domestic bore. There was one participant however who felt strongly on the matter, inferring that people will care more if they have to pay more.

The data here highlights a perceived two-sided approach by the Government, where on one hand they are encouraging garden bores, and the other attaching a fee. One participant (John) implied that it would not be fair to tell you to get a bore and then later make you pay.

Domestic bore owners have come close to also having to paying a $200 a year administration fee (from July 1st of 2007(Kobelke, 2007)) as is paid by commercial, industrial and agricultural groundwater users now. In the end however, the fee was only applied to bores that use greater than 1,501kl a year, an amount considered sufficient to water a 0.2ha garden, normal household use and for watering small herds of stock (Kobelke, 2007). The fees were designed to cover the administration costs associated with the need to licence water extraction, "*It was never the intention of the Government to charge small domestic water users a fee or to cause hardship to retirees, hobby farmers and other life styles*" (Kobelke, 2007, para.6)... "*licensing ensures water is sustainably managed and allocated in a fair way*" (Kobelke, 2007, para.5).

Prior to bore administration and licence fees, a study had been undertaken by Beckwith and Associates (Department of Environment, 2005), where stakeholders on the Gnangara Mound were interviewed on a number of issues, with the notion of water

pricing coming up in those interviews too, both in relation to ground water and scheme water supplies. In these interviews several individuals commented on similar ideas to the participants of this study, such as the view that introducing charges may help curb demand (and therefore use – similar to Claire's views) with others also suggesting that an equitable approach would be to set a quantity of water to meet a household's basic domestic needs and charging this at a certain rate with any volume used over this amount being priced significantly higher (Department of Environment, 2005), similar to what had been suggested by James. Others advocated a system in which the rate paid for water reflected the value society placed on the use of that water (Department of Environment, 2005), with several others arguing that water is presently severely under priced (Department of Environment, 2005).

The data for management and use issues showed that a number of participants had issues in relation to the use of groundwater by market gardeners, with a number also referring to the misuse of groundwater by councils. Several participants felt that alternative water sources (from rainwater tanks to the Ord River) were not pursued adequately. Recommendations made by participants for better management of groundwater resources commonly included the provision of better education for groundwater users on matters that could contribute to more conservative water use, such as knowing how much to use and when to use it. However, a number of participants had also firstly mentioned other water sources that we should be making use of as opposed to more conservative use of the groundwater resource.

Table 3: Brief Overview of Participant Perceptions.

Name	Personal involvement Installing Bore	Reasons for Installing	Perceived groundwater condition	Influencing factors	Consequence of Decline	Gnangara Mound-Resource Boundaries	Ownership	Aware of Managing Body	Decision Making	Recommendations (groundwater specific)
Joe	No	N/A	Possibly in decline	Seasonal rainfall variations; Overuse (market Gardeners)	lose use of bore	Little accurate Idea-northern boundary Gingin	No - tappable for anyone who want to tap it	"Water Corporation"	By authority through setting guidelines	Better management of use
Bob	Yes	Garden	Possibly in decline	Overuse (market Gardeners, Water Corporation & domestic bores due to numbers which exist)	lose use of bore; couldn't think of environmental impacts as he has not witnessed any	No accurate idea (extends to Geraldton)	No-Government Ownership	"Water Supply Department"	By authority	Better example set by government users
John	Yes	Block size, garden	In decline	Overuse (market Gardeners); Climate change - rainfall decline; seasonal variability's	lose use of bore; loss/decline of wetlands	Knew of mound (boundaries not raised in interview)	No - property rights don't extend to that depth	"Water Authority"	By authority	Education & better example by government users
Tom	Yes	In response to dry years	In decline	Overuse ("Water Board" & market gardens)	lose use of bore (prompted to consider environment)	Felt it was a "*fairly large area*"	No - belongs to everybody - nobody has ownership	"Water Authority"	By owner - but acknowledge need for regulation by government	Better use management
Bill	Yes	Block size, garden; cheaper option	Not in decline	None in particular	Didn't know as hasn't seen any decline consequences	Not mentioned	Yes - pays taxes	"Water Authority"	By authority under guidelines	Little to say; perhaps better use management
James	No	N/A	In decline	Climate change-declining rainfall	Affect population growth; flow on effects from drying wetlands (loss of plants and animals)	Not mentioned	No - its our responsibility not our property	"Metropolitan Water Supply"	By him - people should take "responsibility"	Education
Judith	No	Garden	In decline	Growing population increasing demand; Rainfall and wind (evaporation); Seasonal variability	Decline of wetlands and flow on effects to plants and animals; salinity issues	Not mentioned	No- its communal but government has ultimate rights to manage	"Water Supply Department"	By her being "educated" and "sensible"	Education
Susan	No	Block size, garden; cheaper option	Little Decline (localised issue)	Rainfall decline potentially influencing levels	loose use of bore; salinity issues	Not mentioned	Felt she should have - through ownership of property and bore	"Water Corporation"	Authority to set "boundaries"	Education; better management of use

Melissa	No	N/A	Little Decline	Rainfall and increased use	Tree loss	extended across "*several suburbs*"	No - belongs to everybody	Department of Water Resources	By her - she knows when garden needs water or not	Only referred to better use of other water resources
Claire	No	N/A	Serious decline	Over use by all users; Seasonal variability	Loss/decline of wetlands; pollution concentration		No - requires government "only democratic way"	Did not know	By Government - 'only democratic way'	Education

CHAPTER 4:

DISCUSSION:

4. Exploration of Commonly Held Perceptions of Groundwater

This discussion chapter will provide an overview of the commonly held perceptions that were present among the participants of this study in relation to the nature, use and management of Perth's groundwater resources. Some of the major topics influences certain perceptions may have on changing domestic water use behaviour or the implications they may have for management are explored. These will include topics relating to perceptions of the resource itself, such as the environment in which it exists and the nature of its movement, the resource condition and the factors perceived to be contributing to that condition, and perceptions of resource ownership, access rights, decision making as well as overall groundwater management and use.

4.1 PARTICIPANTS AND BORE HISTORY.

The participants for this study were recruited from the suburb of Morley, one of the more established of Perth's suburbs, with extensive residential developments having occurred within the area since the 1950's. The majority of participants were elderly members of the community (60+), with most having lived at their current address for between 32 and 50 years. In light of this, the results are not considered to be representative of data that might be gathered from residents of a different, or newer, suburb or from participants within a different age bracket.

The majority of the participants had their bore installed while they were the occupiers of the property, with most having installed their bores within a few years of moving in and most again having direct involvement in sinking the bore. This involvement in sinking bores might give these participants a better understanding of the nature of the environment beneath them, with all having a perception that there were layers of sand and coffee rock, with most being able to recall the depths they had reached the different layers. Therefore these results may also not necessarily represent the perceptions of bores users who were not involved in sinking their bore.

A small number of participants also had previous experiences with groundwater as farmers (or farmers daughters) or in the previous installation of bores. The two

participants who had stated they had a farming background, both made numerous references to the value they place on water, which they both attributed to being aware of the efforts people have to go to to find and manage their own water supply when external to scheme water supplied areas. It was evident in one of these participants homes that conserving water was indeed a priority for them, having mentioned a number of water collection and re-use methods they used around the home – most visibly obvious.

Two other participants in particular had also shown a genuine concern for Perth's groundwater resources: one had attributed this to lessons he had learnt whilst living in Buddhist temples in India, the other appeared to have a genuine interest and awareness of many environmental issues.

As a group then, the participants are dominated by people having an interest in and experience of groundwater bore issues. The literature supports the notion that experience in a setting can influence people's understanding and perceptions of that setting, which in turn may also influence their behaviour within that setting (Broderick, 2007; Gifford, 2002; Gregory and Wellman, 2001). Broderick (2007) stated that perceptions cannot be easily separated from social conditions. Besides experiences, perceptions are also influenced by factors such as spatial location as well as influences from social and cultural norms (Broderick, 2007). Gifford (2002) found that in many cases where people's lives have been directly impacted by some kind of shortage in a resource, they were more likely to take action and moderate their use (Gifford, 2002). This is not to say all farmers now living in the city value water more than those who have always lived in the city, as needless to say, there are a range of other social and environmental factors that can influence people's perceptions and attitudes towards the environment. Social factors including things like social and cultural norms, ethics, values and religions and environmental factors including value of the resource (importance for survival/lifestyle) and the nature of its existence and many others all play a role in influencing perceptions and attitudes and their influences on behaviour (Gregory & Wellman, 2001)

4.2 PERCEPTIONS OF THE GROUNDWATER ENVIRONMENT.

The common perceptions in relation to the environment in which the groundwater exists, were that most participants perceived there to be layers of coffee rock present throughout the underlying soil profile. Among the participants who had estimated a depth of these layers it was commonly considered that coffee rock layers occur at around 3-4 feet down and then at approximately 30 feet.

Coffee rock had also been said by a few to play a role in containing the groundwater where it is, with participants referring to it either keeping groundwater up or keeping it down. It was suggested by two that there was some kind of impermeable layer below the groundwater to keep it there (having referred to cement and sandstone), however one dismissed this notion thinking that the groundwater is always being recharged from rain somewhere.

There were a number of perceptions in relation to how, where, or if, groundwater flowed, with a number of participants claiming several ways in which it might flow – or not flow. The more common of the responses was that groundwater existed within underground streams. Five participants also referred to the groundwater eventually making it to the ocean, rivers and/or low-lying land (e.g. swamps and drainage soaks), thus implying a degree of flow. It was stated that the groundwater existed between rocks (Melissa), sand (John, Judith, Tom) or both "*rocks and sand*" (James), however in most cases this seemed like a guess rather than an informed position, with many participants having commented on not really knowing or never having thought about it.

Other less common responses included it existing within a reservoir of some kind (similar to Melissa's perception of the Gnangara mound), "*encapsulating the water*" as Joe had referred to it, and like a "*big puddle*" as Bob explained; that over time, as water is removed (via bores), caverns would be created around the spear (Bob); or it's "*just nature*" as Bill explained. One participant, Claire, found it difficult to perceive the groundwater as existing throughout the sand:

> ...it can't really be sucking it out of the sand because the pump wouldn't be able to extricate it at the level that's its coming out through our bore, so there must be pockets of water...not necessarily caverns...it's much too close to the top...but maybe just little strips of channels of water that collect up in little places...

But as John pointed out: *"this is the reason for the slotted pipe [on the bore], that just stops the sand coming"*.

It was commonly considered that the water table was within about 7-12 feet of the surface. While most had specifically referred to a depth, the depth of 12 feet was inferred to by Susan in suggesting her bore was only 12 feet deep (although she did not appear too sure).

Some of the less common responses among the participants in relation to the nature and movement of the groundwater were those mentioned by Bob, Susan, Judith and Melissa. Bob and Susan (more so) perceived that most of what they use on their garden goes straight back down to groundwater, with Susan having referred to this many times:

> ...I think everybody needs a bore, it saves water, I mean, even if you use it, it goes straight back into the ground...

Judith on the other hand wondered if *"we are in some way attached to the Pine plantation"*, saying that she had thought they were *"doing good in the community"* but could not remember if they lifted the groundwater or lowered the groundwater, claiming also that *"trees help stop the saline bit you see"*. Melissa's perception was that taking groundwater away was perhaps a good thing, commenting that her husband had explained that to her once, *"but I can't tell you exactly why"*.

Few studies in the literature have explored groundwater perceptions, in a manner as was explored here. This has created difficulties in both addressing what exactly people need to know about the groundwater resource in order to understand and effectively manage their use of and impacts on that resource and in interpreting the results for use by resource managers.

Gifford (2002, p. 22) refers to a state he calls *"environmental numbness"*, wherein a lack of awareness of our surroundings arises when more lively aspects of the world command out attention and can cause us to overlook major problems. It could be implied that perhaps there is a 'groundwater numbness', wherein people may pay little attention to groundwater due to it simply being out of sight and out of mind.

Evans (2007), noted that there is a lack of technical understanding of groundwater throughout both the general and technical communities, in his case referring to understandings of how groundwater influences surface waters. He suggested that this lack of technical understanding on has led to the problems being faced currently across areas of Australia wherein water has been double allocated as the surface water/groundwater interaction has not been adequately counted for (Evans, 2007).

Evans (2007) explained that to increase community awareness and understandings of the implications of surface water/groundwater interaction represents a major challenge. Effective groundwater management relies heavily on community goodwill because of the scattered nature of bore locations and the resulting difficulty in ensuring compliance (Evans, 2007). Hence, Evans (2007) concluded that good groundwater management is dependent on the good will generated by community understanding of these interactions.

For this study, there was a general sense that most participants did not have an accurate idea as to how the groundwater exists or the nature of its movement with most just having had a guess as to what may be going on below. Apart from this general lack of awareness of the exact nature of groundwater, there were a number of perceptions that could affect a person's understanding of how the system works and potentially their behaviour in that system: i) the idea that water used on the garden goes back down to groundwater; ii) that using the groundwater is a "*good thing*"; and iii) that pine plantations are doing good in the community (from keeping water up...or down). The first two of these perceptions are considered to be of particular importance, as they may influence the way in which people may justify their use of the resource.

Literature supports a notion, that sometimes a lack of knowledge or awareness of the negative environmental consequences of a decision, practice, or action can often act as a barrier to the modification of behaviour to meet more sustainable ends (Suvedi, Krueger, Shrestha, & Bettinghouse. 2000). It is important for environmental educators to address such areas of misunderstandings before proceeding with campaigns designed to alter behaviour (Suvedi *et al.*, 2000; Buyers, n.d.). If people do not perceive that using groundwater on the garden contributes to groundwater decline, then they may not take much notice of campaigns addressing the reduction or restriction of groundwater use because they may not understand why such a thing would be asked. However, if

people know about the negative consequences of their behaviour, but continue to do it, other motivational factors must be at work (Buyers, n.d.).

In relation to the idea that taking the groundwater out is a good thing, could potentially be attributed to the way in which the installation of domestic bores has been encouraged. A number of reports and brochures produced in the late 1990's encouraging garden bores, had stated that using groundwater can benefit the environment in a number of ways, including:

- pumping from garden bores in urbanised areas, where water table rises have been observed, helps to lower the local water table;
- pumping limits the drainage requirements of the developed areas and reduces the environmental damage by a high water table;
- if pumping was to cease, the water table is likely to rise and the potential for flooding will increase;
- garden bores near wetlands may be used to offset the recent rise in wetland water levels brought about by urbanisation; and
- bores also have the potential to lower the wetland levels during the summer months (WRC, 1997).

Although the above statements are potentially genuine benefits to the environment, it could perhaps be argued that the way in which the case for installing bores had been presented, that a number of bore users are perhaps misguided as to the condition of our groundwater resources today and the potential for negative influences arising from their use. These encouragements and the financial incentives offered through government rebates, send a mixed message when combined with an argument that groundwater resources are declining.

4.3 PERCEPTION OF RESOURCE BOUNDARIES.

The Gnangara Mound was brought up unprompted by a majority of participants. However, most were unsure as to where the boundaries of the resource lie, with most again not knowing if they in Morley were within the boundaries of the Gnangara Mound. Only one participant (Claire) directly stated that Morley was within the boundaries of the mound. Others thought that perhaps they were close but not quite

within the boundaries and most perceived it to be a very large area, from "*several suburbs*" (Melissa) to almost "*Geraldton*" (Bob).

As domestic users can be considered part of a common property regime (CPR), and in this case we are considering the Gnangara mound groundwater as the resource, Ostrom's (1990) comments relating to clearly defined boundaries being important within CPR's are applicable. She notes that while resource users have no clear understanding on the boundaries of the resource to which they have access, they will be unsure as to "*what is being managed and for whom*" (Ostrom, 1990, p. 91). In this study, as the participants feel they may be external to the Gnangara Mound, they may not perceive that their use is connected to this resource or that the resource is connected to them. For instance, if they were to hear through the media of significant declines in groundwater over the Gnangara Mound, they may not consider this to affect them as they may perceive themselves external to that system.

The case presented by one participant in that groundwater decline is localized (see next section), is also entwined in the notion of resource boundaries. The degree to which people may see their use as affecting others, or others use as affecting them, may be influenced by where they perceive the boundaries of their resource to lie.

4.4 Condition of Resource and Contributing Factors.

It was considered among the majority of participants that groundwater resources around Perth were, to varying degrees, in decline, with most of these participants mentioning what they had perceived to be the visual signs of this decline – such as those who commented on the disappearance, or shallowing, of lakes and wetlands they have noticed throughout the metropolitan area:

> I think it's terrible...that lake just, to me, just reflects everything that I would think is going wrong underneath the surface, it's just a really visible sign of it... (Claire).

However, there were also participants who felt there was minimal, to no, groundwater decline issues around Perth. Of these, two had acknowledged that perhaps there were localised groundwater issues (Susan) or there were scheme water supply issues from a decline in rainfall (Melissa). Susan's perception on groundwater decline being a

localised issue, could be seen to have contributed to her thoughts in relation to what can help these areas of decline recover:

> I reckon it's localised, I think water is localised like everything, if you're lucky enough to have it, you know...But I don't think it's [using water cautiously] going to help those areas because I think that's just basically the, what their sitting on....

One of these three felt it was difficult for a "*layman*" to comment on whether there has been a decline or not, suggesting that he didn't feel the groundwater is in decline because still he sees water (via sprinklers) being wasted "*all over the different paths and everywhere else*" (Bill).

A number of participants had also specifically referred to the quality of the groundwater, three of which felt that groundwater was perhaps being affected by pollution in the form of oils and nutrients from run-off. The fourth felt there had been no decline in quality, claiming this from not noticing any change in colour or smell over the years (Susan).

Among the responses as to what influences the groundwater levels, seasonal variations, overuse by market gardeners and declining rainfall patterns were some of the more commonly raised. Half the participants had specifically mentioned noticing seasonal variations in groundwater levels, implying that rainfall is a largely contributing factor, with the majority of other participants also referring to rainfall, in general, as being a limiting factor to groundwater levels.

Half again had also felt that the overuse of groundwater by market gardens was a major factor contributing to a decline, sharing views that they used more water than they needed and used it whenever they like. A number of participants had also mentioned their perception of the level of influence domestic users may have, feeling that domestic use could potentially adversely affect the groundwater levels, mentioning that there would be some who would abuse it and that there are so many around.

One participant's view that domestic users would have little, if any, impact on the groundwater, stemmed from her perception that what was used on the garden goes back down to groundwater. Another participant did hold this view, however he had still felt

that domestic use could negatively influence groundwater levels because of the number of bores around (Bob).

A number of participants also referred to climate change as influencing the decline in rainfall, contributing to the decline in groundwater. It was perceived by only a few that the Water Corporation's groundwater abstraction was also affecting groundwater levels.

In relation to the consequences that may arise from a declining groundwater level, participants claimed that people are going to either lose their water (decline beyond the reach of the bores) or no longer be allowed to use what's there. It had also been considered by one that this decline of groundwater would contribute to a slowing of growth around the city as water becomes more scarce and another also referred to the population as a limiting factor on water conservation (more people means more pressure on water supplies.

In relation to consequences for the environment, the majority of participants had mentioned some kind of environmental consequence (although most required prompting to consider the environment). The most commons response was the loss or decline of wetlands (although some were further prompted to consider these environments) as well as other flow on effects, such as the loss or decline of animal and plant species and salinity issues.

In a commons dilemma, as a resource becomes scarcer, people usually act more in self-interest to ensure their own survival, livelihood or lifestyle, than consider the long-term sustainability of the resource and act in the best interest of the community (Thompson & Stoutemyer, 1991). However, in this study it appeared that those who perceived the groundwater to be declining, in most cases, were those who also felt that groundwater should be better managed and conserved.

In the study by Suvedi *et al* (2000) the willingness for farmers to change farm practices to protect groundwater was positively related to how a farmer perceives the seriousness of the problem. Buyers (n.d) and Gifford (2002) also both stated that knowledge of environmental issues was a factor that can influence environmentally responsible behaviour, as is environmental concern. This notion may apply in this case in that the degree to which people are aware of groundwater issues, the more likely it may be that

they will understand why their use requires restriction and furthermore, it's more likely they will abide by such restrictions. However, knowledge alone about environmental problems is often not enough to change behaviour, as Moore (1994) pointed out in her longitudinal study on water conservation behaviour: while knowledge was linked to behaviour, she found the association weak in the long term.

4.5 Perceptions of Groundwater Use and Management Issues.

4.5.1 Groundwater Restrictions.

Most participants were aware that groundwater restrictions were in place and had been commonly accepted by most participants, some more strongly than others, and one who was not too keen on having to water on a pre-determined day. However, there was one instance where I was unsure whether the participant was aware of the restrictions.

Those who were ambivalent to the restrictions had varying reasons as to why they were not completely happy with them. These varied from the difficulty in setting reticulation timers to obscure days; the difficulty for wheelchair bound people to use a hose for watering on a non rostered day (as hose watering is allowable any day between 6pm and 9am); and restrictions were not really necessary because they didn't feel Perth has that much of a decline issue, but supported them as a means of getting people to do the right thing (and conserve water). One participant (Melissa) was not being keen on the restrictions because she likes to decide herself when to water. On the broader scale this participant had questioned the effectiveness of the restrictions, referring to people ignoring them because of the perceived value of their garden.

In 2001, a study on domestic bore ownership and usage patterns, based on survey results of 761 individuals, showed that 64% respondents had agreed that bore use should be restricted to between 8pm and 8am, with the rest either unsure or not in support (WRC, 2001). Although the actual bore use restrictions turned out to be different than what was suggested in that study, the majority in both cases had generally agreed with groundwater restrictions. This is an important aspect because if bore users feel the restrictions are reasonable (or necessary), they are more likely to adhere to them.

It was also found in the literature that efforts to change behaviour through education, were often more successful in altering behaviour if combined with other measures such as restrictions (Moore, 1994; Syme, Nancarrow and Seligman, 2000)

Two participants however, had questioned the way in which the restrictions had been introduced, one claiming he was expecting to see something in "*black and white*" (James) with the other (Claire) claiming the Water Corporation had gone about it in unclear and ambiguous ways, which meant a number of bores owners were perhaps not getting the message (see below).

4.5.2 Perceptions of Domestic Bore Fee's.

The common response to whether or not domestic groundwater users should be charged for their groundwater use was no – with one suggesting if a fee were introduced, it should be for new bores only (Susan). The majority of these disagreed with any charges because another fee would put too great a strain on their budget (considering a number are living off retirement pensions). Another three participants had stated that they would not mind a fee, with one (Claire) in particular feeling it would be a good idea as she believed it would make people pay more attention to their use.

Prior to bore administration and licence fees being applied to industrial users, a study had been undertaken by Beckwith and Associates (Department of Environment, 2005), where stakeholders on the Gnangara Mound were interviewed on a number of issues, with the notion of water pricing coming up in those interviews too, both in relation to ground water and scheme water supplies. In these interviews several individuals commented on similar ideas to the participants of this study, such as the view that introducing charges may help curb demand (and therefore use – similar to Claire's views) with others also suggesting that an equitable approach would be to set a quantity of water to meet a household's basic domestic needs and charging this at a certain rate with any volume used over this amount being priced significantly higher (DoE, 2005), similar to what had been suggested by James. Others advocated a system in which the rate paid for water reflected the value society placed on the use of that water (DoE, 2005), with several others arguing that water is presently severely under priced (DoE, 2005).

Winpenny (1994) suggested that water, becoming an increasingly scarce resource across the world, is severely underpriced. He noted how price was a measure often used to control the demand on resources, and further noted that as water is a necessity of life, there are limits as to how much price can be used to control water consumption without raising equity and ethical issues relating to those who possibly could not afford such increases in price (Winpenny 1994)

There were also equity issues raised within this research. One participant had suggested that if a fee for bore use was introduced then only new bore owners should be required to pay it. While another suggested that it would not seem right for the government to suddenly start charging for something after they had encouraged people to get bores in the first place. As many saw it as a cheaper option than scheme water for the garden, many had installed a bore for the perceived savings, therefore the idea of a fee being attached, they felt, may defeat such a purpose therefore possibly meaning that more people would remain using scheme water, a costly option for society.

4.5.3 GROUNDWATER OWNERSHIP.

In relation to groundwater ownership, most participants considered that the groundwater beneath their land was not their property for reasons such as that stated here by John in relation to property ownership:

> Not really, because according to law, ...you only own a certain depth of your land and its not very deep...so you don't actually own the water no...

Of those that felt there was no ownership by users, the majority felt that it was a resource for everyone, with nobody having direct ownership rights, as stipulated in Tom's response: *"The country owns the water... you know, everybody owns it, nobody has ownership of it"*. In relation to who can use the resource, a number of these participants held perceptions similar to Joe, in that it's a *"tappable situation for anybody that wants to tap into it"*. Therefore it may be interpreted that the majority of domestic bore users in this study feel that groundwater is something to which nobody has ownership but which everybody can use, providing they have access (via a bore).

This is a similar notion to that as was described by the Water and Rivers Commission in the earlier literature review as a usufractuary property right, wherein a person has a right

do enjoy something they don't necessarily have any degree of ownership in (WRC, 1998). It could be used to explain that the majority of users do perceive the groundwater as a commonly owned resource to be shared among those with access, and that no one has any direct ownership. A majority of participants, in a separate discussion, had mentioned that ultimately decision-making should come down to the managing authority (see later section). This could be interpreted to mean that while they perceive that nobody has ownership, and that anyone who can access it can use it, they also feel that it does require a degree of organised management.

There were a also a number who felt that, in a sense, the government would have the ownership and be responsible for managing it for the people:

> Well I suppose that I would have to say the Government would have to have the rights to it because we've got it... that would be the only democratic way for it, it's just that sometimes, sometimes people don't understand the things for their own good in the long run and so yeah, I would have to say it's a Government responsibility to make those decisions (Claire)

Those two participants, who felt they did have ownership, justified their reasoning by either reference to paying income taxes, and therefore automatically qualifying to use it (Bill), or in relation to notions of property ownership:

> Well it should be [ours], I think so, but I don't know what the Government thinks...because the property is mine, you know, we purchased it, we paid for it, we found the water, we put the bore down, we have a few reasons to say that it belongs to us... (Susan).

There were few instances in the readily available literature that addressed an exact depth to which property rights extended beneath the surface, a problem to which Newell (1999) had faced, and answered by way of analogy of how the common law cases dealing with the physical ownership of airspace may be applied to the case with land, and as she argued, groundwater also. She used the notion from the case of *Bernstein v Skyviews and General Limited* (*Bernstein* 1978, cited by Newell, 1999, para 16) which held that the "rights of a landowner to the airspace above his land was restricted to such a height as is necessary for the ordinary use and enjoyment of the land and the structures upon it".

If applied to land and groundwater, as done by Newell (1999) she questioned then how much land and water do land owners need to use and enjoy their land as outlined in the case above? (Newell, 1999). To make it clear, the Crown allocates up to 1500KL per annum for a domestic premise within Perth - sufficient to water a 0.2 hectare garden, normal household use and for watering a small number of animals (Department of Water, 2007).

The privatisation of common pool natural resources is often a suggestion, as with private property comes the rights of exclusivity to the resource (Martin & Verbeek, 2002). Ostrom (1990, p. 12) cited Robert J. Smith (1981, p.467) to have suggested that "the *only* way to avoid the tragedy of the commons in natural resources and wildlife is to end the common-property system by creating a system of private property rights". Ostrom (1990) added that while allocating private property in land is relatively easy, moving entities such as water are not so, therefore it is unlikely that any degree of exclusive ownership can be applied to the case of groundwater. This would imply that better management and conservation of groundwater will have to come through other means (education, restrictions, pricing) other than creating private property rights in groundwater.

4.5.4 Awareness of Groundwater Management Body.

In relation to who was the managing body responsible for groundwater resources, the majority had answered that they thought it was the Water Corporation, although their names for this authority varied. One could not say who managed it (Claire) while Melissa had said the Department of Water and Resources.

In a study by Carruthers, Latcham & Pudney (2006), which looked at changing the perceptions and knowledge barriers among a group of groundwater license holders in South Australia, found that policy makers who spent time building relationships and trust with the broader community, assisted in enabling broad community attitude change. The fact that most participants (in this study) were not aware of the Department of Water, and therefore also not aware of its regulatory role, having instead referred to the Water Corporation as being the groundwater management body, suggests that, particularly if this perception was common across the broader Perth community, the

Deprtment of Water may need to consider possible awareness raising campaigns in relation to who they are and what they do.

4.5.5 Perceptions of Who Should Make Decisions on Domestic Groundwater Use.

The majority felt that ultimately decisions on how people use their bores should come down to the body responsible for groundwater resource management, some suggesting this as a means of better controlling peoples use, "*I don't think it's something that we can just be allowed to use because we will abuse it and it isn't as if you can recoup it, you can't fix it*" (Claire). And as another said, "*the guidelines are set down and the individual is to follow the guidelines*" (Joe).

Those who felt they should make the decision about their use, felt this way for varying reasons, one mentioning that it's because she is "*educated*" and "*sensible*" she should be able to decide how to use her bore (Judith); while another (James) stated it as being a responsibility thing:

> ... it's each house owner's responsibility to make sure they don't water their garden too much...that's the main thing for me, is for people to take responsibility, and be a bit careful,

Of those remaining, one felt that because he owns the bore, he should decide how its used, with the final reason being that this participant (Melissa) liked to decide herself when her garden needs water.

The majority of participants felt that the government should make the decisions on domestic bore use. This coincides with that reported by McFarlane (2005), who noted that as people come to recognize the value of water, driven through scarcity in some areas, they usually want government to make any hard decisions, especially in the areas of equitable water sharing. McFarlane's report also noted however, that most people want to be involved in the decision making, a perception that was not clearly displayed in this study where only two participants said they would be interested in attending forums on groundwater use and management, with most others saying either their presence wouldn't be needed, it's something that doesn't really concern them, the

scientists would take care of it or they would only be interested if it was something that was likely to upset them.

Of those who felt it wouldn't concern them, some attributed this to their feelings of not being around for that much longer therefore were not exactly worried about what will happen in the long term. This lack of a long-term vision for the resource has been highlighted by Ostrom (1990) as a factor that can greatly influence collective action and choice arrangements.

4.5.6 Perceptions of Groundwater use and Management Issues.

The commonly held issues people had in relation to how groundwater was used revolved around the perceived excessive use by market gardens, with four having directly referred to it as a management issue (although numerous others had felt they were contributing to the decline). Three participants also referred to the misuse of irrigation water by councils, with a further two also mentioning the abstraction by the Water Corporation as potentially influencing groundwater levels.

As Gifford (2002) noted, the degree of equality among harvesters can affect cooperation between harvesters, and cooperation among users is a crucial aspect in managing common pool resources, especially at the stage of a dilemma or potential dilemma. As several of the participants had noted the excessive use of groundwater by market gardeners, there could be feelings of 'well if they are taking that much and taking it as they like, then why can't I', or also it could contribute to feelings that there is plenty of water because of the amount being sprayed around everywhere –as one participant (Bill) expressed.

A number of participants also referred to the issues they had with missed opportunities such as the capture and use of storm water and missing out on water from Wellington Dam and the Ord River, while another felt the government was not doing enough to properly manage all our water resources, and another had issues in relation to bore water use restrictions not being made clear. As so many participants had suggested making better use of other water resources, it could be interpreted that while most were aware that groundwater was declining, they were not so inclined to better manage and

conserve what we have, but rather deflect the issue and obtain water through other means so as to avoid any water shortage.

Among the recommendations participants made in relation to better management of groundwater resources among domestic users, five participants had stated that they felt that more education of groundwater users was required. Some commenting that they felt that people should be more educated on how much and when they should be watering, informed of the more water efficient products, with even suggestions to teach people about the resource (where it comes and where it goes) and what's going to happen in the future. To a lesser extent it was also suggested that metering of domestic bores may also assist in managing use, as bore users would then be aware of how much water they are really using.

As Syme *etal.* (1999) pointed out, water agencies have long conducted educational campaigns as a means of informing people how to save water –both by attempting to alter water-use behaviour and by encouraging water efficient products. In Western Australia raising awareness of the need to conserve water, and educating consumers on how to reduce their scheme water use, has been a feature since the onset of the 1970s (McFarlane, 2005; Syme *et al.,* 1999)..

A number of participants acknowledged that we do have educational campaigns about saving water, however, they felt that these did not address groundwater specifically and felt that the campaigns really needed to be that specific. However, some did wonder on the effectiveness of such educational programs – some saying there are certain people that can't be educated or who don't take notice, while another suggested that TV education doesn't have the same effect these days.

The effectiveness of such campaigns have also been widely debated throughout the literature. Through literature reviews, Syme *et al.* (1999) found that those in support claimed that they do contribute to water conservation, are politically acceptable, increase a sense of conservation as socially responsible behaviour, and can lead to behavioural changes that can result in long-term reductions. Critics however claimed they are not cost effective, voluntary behavioural change is often short-lived, and that other means, such as pricing, restrictions and improvements in technology, are more effective in reducing long-term reductions in water use (Syme *et al.,* 1999).

Results from a study by Thompson and Stoutemyer (1991), which focussed on water use as a commons dilemma, showed that education interventions that focused on the long-term consequences of water use and the personal actions to conserve water were likely to be more effective in reducing residential water use than to base the message on the economic savings in reducing water use or by giving tips on how to save water.

Their study also showed that upper-middle class areas (as opposed to lower-middle class areas) had appeared unaffected by either message in the campaign, which led them to the conclusion that in the middle-upper class areas there was a greater likelihood of large lawns, automatic sprinklers and swimming pools, which may affect the degree to which water can be conserved (Thompson & Stoutemyer, 1991). This literature coincides with the thoughts a number of participants had expressed in relation to the perceived value of people's garden influencing the degree to which they use water. Those who value the garden more, or gain pleasure in gardening, often are more likely to use more water than others who place less value in their garden, either recreationally or as a means of improving property re-sale values (Clayton, 2007).

Before policy makers develop educational campaigns for conservative water-use, Thompson and Stoutemyer (1991) highlighted three important factors that should be considered, from the viewpoint of water as a common resource, these including:

- commons dilemmas often involve conflict between short-term (self interested) and long term interests (best interest of the community);
- the restrained use of a resource in daily life involves short-term sacrifices for the long-term benefit (Thompson, 1991); and
- there is a common perception in dilemmas that an individual's actions are ineffective.

In their study, Thompson and Stoutemyer (1991) reviewed both successful and unsuccessful campaigns to determine which factors can contribute to changes in water-use behaviour. From this they had concluded that educational messages needed to be fairly extensive, in relation to detailed information on the nature of the situation and its consequences to resource users, in order to be successful at influencing behaviour. They highlighted the importance of awareness raising on the long term consequences of resource decline, as a means of overcoming self-interested values so that focus on the

long term plays a stronger role in the decisions people make about their behaviour (Thompson & Stoutemyer, 1991). They also noted that educational messages needed to be strong, repeatedly presented and focused on the importance of individual action (Thompson & Stoutemyer, 1991).

While literature reviews on conservation evaluation measures by Syme *et al.* (1999) failed to find significant demonstrations of long-term water use reductions, they acknowledged that education campaigns can result in saving up to 25% in short-term or crisis situations, which they felt to be significant.

4.6. CONCLUSION.

This research project investigated the commonly held perceptions domestic groundwater users have towards groundwater resources, use and management around Perth. The array of perceptions showed that in most cases the majority of participants felt much the same about a number of factors such as groundwater condition, nature and movement, ownership rights (or lack thereof), issues with use and recommendations for management.

The majority of participants installed their bore themselves and this appeared to contribute to their awareness of an underlying geology. Previous experiences in water scarcity whilst living on farms in rural Western Australia were important for some. In relation to how and where the groundwater comes from, and where it goes, most were hesitant in describing the groundwater system, but there was a general perception that it exists within streams and flows through the geological strata (rocks and sand). Few also had any accurate idea as to where the resource boundaries lie, which can create implications as they will be less likely to understand what may affect them and what won't and what is being managed within the resource and for whom (Ostom, 1990).

Most acknowledged that rainfall and potential overuse might be contributing to the decline in groundwater levels. The majority were also in acceptance of the groundwater restrictions, with a number having stated to have always stuck to the scheme water restrictions when they were introduced. However, one must keep in mind the often disparity between reported behaviour and actual behaviour as pointed out by Syme *et al* (2000).

The degree to which participants perceived the resource to be that of a common pool resource, stemmed predominantly from the fact that the majority did not perceive that they, or any individual, has any degree of ownership over the water beneath them, but varied in the degree to which they perceived the government as having ownership or vesting rights over the resource. The majority had felt that ultimately the managing body should make the decision on how domestic users can use their bore, however few were interested in taking part in this decision making role – a crucial aspect for collective choice arrangements (Ostrom, 1990).

There were a number of interesting connections linked to the perceptions held by a minority that were not further explored because some opened up a world too complex to be fully catered for in a study of this nature. Of the two participants that stood out, one had felt that there was a lot of groundwater in Perth, he could not think of any consequences of decline as he had not seen any happen locally, he felt he owned the water because he paid his taxes and, and due to the nature of the question, had been unsure as to whether he was aware of groundwater restrictions being in place. The other example was one who felt the groundwater wasn't all from rain but it was just the way in which God had created it; she also felt that Perth did not have a groundwater decline issue, but rather it was localised to smaller areas; she felt her property rights should extend to the groundwater beneath her, she didn't think the restrictions were necessary, and; she felt that most of the water she used on her garden went straight back into groundwater. As Evans (2007) concluded, good groundwater management is dependent on community understanding of the interactions between groundwater and the environment.

Some of the main findings that may be of interest to resource managers are those relating to equity in regards to fees being applied to groundwater use, wherein some felt that the introduction of groundwater use fees to domestic users would not be appropriate after the government had encouraged such installation of bores in the first place. There was also an issue with the mixed messages being sent by the government, where on one hand they encourage the use of bores (to save on costly scheme water) and provide incentives to do so, while on the other they claim groundwater resources are declining.

There were also issues surrounding some misconceptions that could potentially make difficulties in raising peoples understanding as to how the groundwater system operates and how we can impact it – such as that relating to the perception that what is used on the garden contributes back to groundwater. Furthermore, being that most were unaware of who is actually responsible for our groundwater resources, they would be further unaware of the roles and objectives to which this department operates by. It was also revealed that rather than adjusting use and management to suit our current water resources, most participants' chose to deflect this issue and instead recommended how we should be making use of other water resources as a means of creating a better water supply.

There had also been he expressed need for better education of groundwater users, with some particularly emphasising that the introduction of groundwater restrictions was not made at all clear. They had suggested that there should be a range of education campaigns, form TV advertising, newspapers, education in schools, with even suggestions that scheme water bills should provide information on restrictions applying to bore use as well. While the long-term effects of educational campaigns to increase conservative behaviour have been argued (see discussion), they none-the-less can at least improve peoples' general understanding as to the nature of our groundwater resources and why we must use water wisely, hopefully a few at least would adjust their behaviour and pass those values onto their children

To enable us to better manage out water resources, managers need to work closely with and engage the community so as to build their knowledge, awareness and understanding of the issues facing us so that we can together better manage our natural resources for the future (O'Brian, 1995).

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APPENDIX A

Rainfall and Dam Inflow Decline Figures

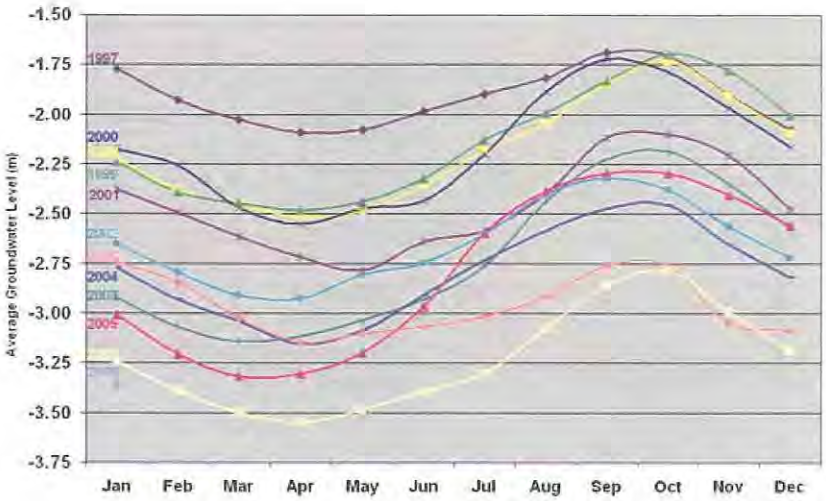

Figure 1. Groundwater levels depicted on the graph are based on data taken from over 50 bores located across the mound's superficial aquifer (DoW) nd).

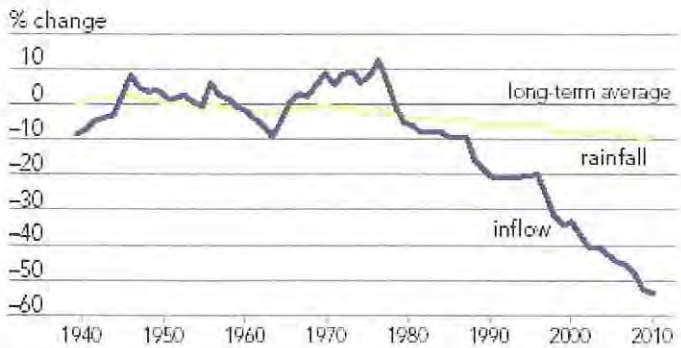

Figure 2. Thirty-year running averages of natural inflow into Perth dams and rainfall over SW Australia (PMSEIC IWG, 2007)

Tables of Inter-coder Reliability Outcomes

Comparison of Codes: Interview 4: Coder 1 (PH)	Same	Missed by researcher	Missed by coder
Hydrology Nature and Movement	3		1 (coded to condition node)
Condition	2	2 (1 coded to management & use issue, 1 to nature & movement)	
Ownership	1	1 (coded to decision making/ responsibilities)	
Decision Making/Responsibility	1	2 (1 coded to who manages, 1 to management & use issue)	
Who Manages		1 (coded to responsibility)	1 (coded to responsibility)
Management Issues	1	2 (1 coded to bore background, 1 to management recommendations)	1 (coded to both who manages and responsibility)
Perceptions of Regs	1		
Perception of Fees and Charges	1		

Comparison of Codes: Interview 4: Coder 2	Same	Missed by researcher	Missed by coder
Residence	1	1 (coded to Nature and Movement)	
Bore Installation	1		1 (not assigned)
Experience	1		
Boundaries	1		
Condition	1	1 (coded to mgt issue)	1 (not assigned)
Nature and Movement	1		2 (1 not assigned, 1 coded to residence)
Ownership	1		
Responsibilities/decision making			1 (coded to fees and charges)
Who Manages	2		
Mgt Issues	2		1 (coded to condition)
Mgt Recommendations	1		
Perceptions of Regs.	1		
Perceptions of Fees and Charges	1	1 (coded to decision making)	

Comparison of Codes: Interview 12: Coder 1	Same	Missed by Researcher	Missed by Coder
Nature and Movement	8	2 (1 coded to mgt issue; 1 not assigned)	
Condition	4		1 (coded to mgt issue)
Ownership	1	1 (coded to bore details)	
Responsibilities/decision making	1		1 (coded to who manages)
Who Manages	2	1 (coded to decision making)	
Mgt Issues	2	1 (coded to conditions)	1 (coded to nature and movement)
Perceptions of Regs.	3		1 (not assigned)
Perceptions of Fees and Charges	2		

Pilot Tests – Methods and Results

Overview

A preliminary pilot test was undertaken (with a friend) in the very early stages (pre-proposal submission) to assess the applicability of the original project idea, which was to develop a screening questionnaire and an in-depth interview guide. The screening questionnaire was intended to act as a means of participant recruitment and selection as well as to provide general background data about the participant community.

However after this initial trial of this interview structure, undertaken off the record for preliminary research only (not recorded), and following the proposal review, it was decided that the screening questionnaire should be excluded from the project. As the idea behind the research project is to gain a 'quality' of information rather than a 'quantity', it was decided that time restraints may not allow for both (screening questionnaires and interviews) to be effectively and efficiently carried out. For instance, not enough people may be contacted to allow for the representativeness of data generated from the screening questionnaire and/or insufficient time may be left available for deeper analysis, development and reflection on interview methods and transcriptions.

In the early stages it was difficult to develop an interview guide based around open ended, non-prompting, questions which could be used to explore people's perceptions to bore use and groundwater. However, as the piloting went on, new questions were developed as conversation topics were explored, these were then tried in following pilot interviews to further develop the interview guide.

The official pilot tests were undertaken initially using convenience and snowballing techniques. Meaning that people known to the researcher as having bores were contacted for participation (convenience) and also others, unknown to the researcher, who were 'discovered' by asking friends-to-ask-friends who had a bore (snowballing)

Neuman (2000) describes convenience sampling as potentially being highly ineffective and producing unrepresentative sample participants. However, he also notes that they are quick and cheap (Neuman, 2000), and considering time and money are always a limiting factors present in Honours research projects, it was considered that this method would be suitable for use in the pilot stages in limited numbers only.

Other pilot participants were to be found using a technique similar to that of snowballing. Snowballing, also called network, chain referral or reputational sampling, is described by Neuman (2000) as a method for identifying and sampling the cases in a network. This notion roughly applied during the pilot tests as people known to the researcher were contacted and asked to ask around for others they knew who had a bore.

Overall seven pilot interviews were undertaken, out of these a majority were relatives, either directly, by law, or as part of extended family (4 total), one was undertaken with a friend, and two interviews were undertaken with people more unfamiliar (one had been briefly met before). These interviews varied in length from18 minutes to 36 minutes (average 27 minutes).

A brief door knocking round in the local area the research students local area to 10 homes proved unsuccessful, as those that were home (4), none had a bore. It is hoped that when undertaking participant recruitment within the study area (Morley) it will not be as difficult to find homes with bores as 75% of homes there do (EPA, 2007)

A letter drop, in the local area again, was carried out with 10 homes (that had lovely green gardens and a few having iron stains– both possible signs of a bore) receiving a letter requesting that they contact me if they are interested in participating. No responses were obtained, which may be due to the fact that firstly, the information letter stated that the interview was for pilot testing only, therefore people may have been less inclined to help as they may have felt that their say wouldn't matter; secondly, perhaps people did not like the idea of being recorded (as was stipulated in the information letter) or; thirdly, perhaps people just aren't interested in such a project or are not interested in participating in such a project?

The initial themes of the interview were:

- Theme 1: Background and context building – This theme was designed to explore a little about the participants past experiences and lifestyle as well as their current situation in relation to their bore. Questions under this theme explored:
    - Where has the participant lived (e.g. country/city)/what has their lifestyle been like (e.g. farm or apartment)?
    - Had they ever had a bore before, what was that like (quality/quantity etc.)?
    - How long have they lived at this address?
    - Was the bore already fitted or did they install it themselves, if so, what were some of their reasons?
    - What can they tell me about their bore
- Theme 2: Perceptions of Resource; Access, use and the groundwater system – This theme was designed to explore their perceptions towards their bore and its connection to the groundwater as well as exploring their understanding of water movement through the environment, impacts of groundwater abstraction and general groundwater management understandings (restrictions etc.). Questions under this theme included:
    - Asking the participant to draw how they see their bore and the resource and to describe what they know about how the water interacts above and below ground (where does the water come from, how does it get to the water table and does it go anywhere?)
    - Exploring what they know of the current restrictions and what they think about them?
    - Exploring what they think may occur as a result of groundwater use (what some of the consequences may be)
    - Explore their views towards groundwater use management – who do they think should make the decisions about how they use their bores?

Throughout the pilot testing process, the interview guide had taken on many changes (see Appendix D for initial guide) for final pilot interview guide), as more topics and issues surfaced throughout the conversations in the pilot tests, more themes and issues were identified for possible inclusion as question themes into the final interview guide (see thesis Methods)

As piloting continued, the themes over time were further divided into 3 categories, with the original Theme 2 being further divided into;

- Perceptions towards local hydrology
- Perceptions to access, use and management

Results and Discussions

Pre-Interview Techniques

During the pilot tests it became obvious quickly that a bit of an overview was required to be given to the participant to give them a better idea and understanding on what was going to be discussed. Most interview situations require a degree of instruction to be given to the subjects to *"set the stage"*, as Neuman (2000, p.140) so described it. Neuman (2000) also recommends that a researcher should give carefully worded instructions prior to undertaking the interview and follow the same script so that all the participants hear the same thing- thus helping to assure reliability.

Some participants were at first over whelmed by the topic, admitting that they did not know much about groundwater and weren't sure if they would be helpful. Once they had been further informed they appeared to become much more at ease, feeling that rather than a test it was more a discussion. After this explanation, some participants had expressed that they felt a little more prepared knowing what we were going to discuss. The overview supplied to participants has been included within Appendix E.

Response to Recording

Most participants joked about 'being careful what they said', but over all they all appeared relatively comfortable to be recorded. Two participants had mentioned that they had previous experience carrying out interviews while being recorded and so both appeared quite un-phased about the whole thing. Some participants (2) even forgot it was being recorded until it had been said that the recording was about to be stopped.

Theme 1 – Context Building

The questions used here were designed to explore a little about the background of the participant and also as a means of getting them comfortable with the interview situation. The question was usually worded around the following:

Could you please tell me a little about yourself and how you came to be living here?

Although all may not have been asked for directly, several topics were covered during conversation stemming from this question, including: their time at current residence; previous place of residence (country/city, farm/ apartment); how they came to the decision to move (to current address); had they had a bore before; and, did they install this bore?

Such questions helped in creating a picture of the participant's background and explored factors which may be been seen as potential players in the influences which drive peoples perceptions, behaviours and attitudes towards the environment or conservation

for example (Buyers, n.d.). As a starting point, this theme was also considered as a means of getting people more relaxed and talking as it is a subject that most people would be comfortable talking about as it is something they know before getting onto the more specific themes of the interview.

After the second pilot test another question idea of whether or not the participant had any other previous training or experience in working with groundwater resources was introduced. After the third pilot participant had mentioned to have once been a drillers off-sider, a position to which he attributed his knowledge of groundwater to, it was considered a useful question in addressing what past training and knowledge people may have about groundwater which could influence other perceptions they may have ((i.e. perhaps those who have learnt of it/ or worked with it before may have a better understanding of how the system works?). The remaining pilot participants were asked this question. A majority did not really think they had any experience relevant to groundwater, one had said she was a Social Studies teacher and Geography teacher at primary school (PP6) who covered the water cycle as part of the unit curriculum, and another had learnt of things just through her own community interests (PP7) (her neighbourhood had a history of groundwater contamination events).

Theme 2 – Perceptions Towards Local Hydrology

The first part of this theme asked the participant to draw how they perceive their bore connecting, or reaching, the groundwater resource:

> Could you please draw for me a rough diagram of your bore and the resource, something that could show me where the water comes from and how you use it?"

The concept diagram idea was developed as a means of getting a picture of how the participant's perceive their connection to the resource via the bore, as well as the nature and dynamics of groundwater (where from; where to, and; how it 'exists').

When first asked this however, most participants were unsure of what was meant. So further explanation was given in the form of "just imagine you are standing out the front and you can see above and below ground". From here most suggested was it to be like a cross sectional diagram – which was the idea. This really got people actively thinking about how their bore connects with the groundwater and in most cases worked very well in creating a somewhat conceptual diagram of how the groundwater system exists.

Using this diagram participants were also asked how the groundwater 'existed' below, where it comes from, how it gets there and whether or not it goes anywhere? This really got participants thinking with some admitting its something they had never really thought about (PP2, 3, 4, 7) and that they had to try and remember right back to high school geography (PP2).

The diagram worked well in the piloting phase as it appeared to help as some sort of a visual aid for the participant and helped them to picture what it was they thought they 'saw' when they were asked how the groundwater exists and so forth.

The range of diagrams and knowledge of the nature of existence of groundwater varied as the participants were from wide ranging backgrounds. Some had never learnt much of groundwater at all, admitting that it was in high school that they had last studied geography or anything to do with the water table. While others were more knowledgeable, with one being a petroleum hydrologist, one a Social Studies/geography teacher (PP6), and one had previously worked for the Department of Conservation and

Land Management and had done University Degrees (PP5), which covered the water cycle and the nature of groundwater. Therefore, some diagrams were very descriptive (showed varying soil layers at depth etc.) where as other were more simple (just a line between the land surface and a depth to the bottom of the bore).

Theme 3 – Perceptions to Access, Use and Management

This theme discussed topics such as use issues and restriction; who's responsible for groundwater resource management around Perth; how they perceive the state of the resource (good or degraded, why?); what consequences may result from groundwater use; are they aware of restrictions – what do they think about those; what would they think if a charge was attached and other questions of a similar nature. Questions relating to ownership and access rights were introduced mid way through the pilot tests and appeared to be a very useful way of exploring how much ownership they perceive themselves to have, or not have, over groundwater. This would help address the question as to whether the users of this resource recognise the property regime they are part of in relation to this resource (that being common property (domestic/stock use)).

The way in which questions were worded also needed careful consideration so as to not overly direct respondents to think too narrowly or to answer a certain way. Through peer-reviews of pilot transcripts, question wording was analysed and alternative means of addressing the questions were explored if they appeared too direct, ambiguous or similar such wording errors. However, as is the nature of qualitative research, many researchers often do not follow a set question order or question wording, but shape the question to the conversation at the time– i.e. whether or not the participant had already mentioned something, or not, affected how a question was asked. For instance, if they didn't know of restrictions they were asked if they knew of any, and, if they had mentioned restrictions themselves, the conversation generally started with "so what did/do you think of the restrictions" for example.

On the topic of restrictions, most participants were well aware that restrictions were in place, however two participants had only recently become the owner of a bore and were unsure on bore restrictions, with one saying that they "had been just sticking to the 2 days a week water roster for mains just in case" (PP2).

After the third interview a new question idea of who they thought managed the groundwater resources around Perth was introduced. Three out of the remaining four interview participants had said the Water Corporation was responsible for managing the groundwater, the other, a former officer with the Department of Conservation and Land Management (CALM), suggested it was the Department of Environment (PP5) (which was the former managing body before the Department of Water). Implying that possibly few were aware of the Department of Water (what has caused this, a lack of community education on who manages groundwater, or ignorance from the community?). The second participant, who had brought up the question herself about who manages the groundwater, felt it would be local Councils as she thought that "local councils should make the decisions on bore use" as she felt "they would have a greater idea that the State Government would".

There were mixed results when participants (latter 5) were asked how they would feel if a charge was attached to the use of a domestic bore, some, like participant 3, felt "it would defeat the purpose of having a bore" and that depending on what the charge was, he thought that a "usage fee would see to people using tap water instead, as it doesn't stink" and thought that this would be a worse off scenario as "using bore water doesn't

draw on the dams for the drinking water supply". Participants 4 and 7 also shared similar views, with 'PP7' admitting that although she wouldn't like it, she thought it may encourage people to care more for it and conserve it more.

Participants 5 and 6 were very keen on the idea (participants 5 and 6 were sisters and shared very similar views) saying that you might make people care a little more if they had to pay for it, with '5' adding further that "it may be difficult to regulate as some people may not report their bores" and that "it would be a very political thing to introduce".

Addressing the issue of ownership was difficult, as I did not really want to directly address it, however was unsure how to go about it otherwise. It was then decided that although asking it as " who do you think owns the water – do you feel you have a degree of ownership?" was perhaps considered a little too direct, it was one of the better ways to try and ask for the information be sought (i.e. do they see it as a shared/common resource?). It was decided that this question would still be used, however, during the interviews I would make an effort to word it in the same way every time and discuss how participants went about answering it and what their reason why were (why they felt they owned it/didn't own it?). In discussing ownership, it was surprising that no pilot participant really felt they had a degree of ownership over the water, sharing similar thoughts on it being a shared resource, such as participant 4 who had said she had "never really thought of it as their own... it is something that has to be shared".

Transcription and Analysis

All pilot interviews were downloaded from the Sony IC Recorder onto a computer using the Sony Digital Voice Editor program. From here the file is converted into a WAV file and imported into Express Scribe, a program that runs with a foot pedal (V-Pedal) to control the playback of the recording to aid the transcription process. Once transcribed the transcription is cut from Express Scribe and imported to a Microsoft Word document for review.

The first 3 piloting transcriptions were also imported into Nvivo 7, a software program designed to help code and analyse qualitative data. Here the researcher developed a draft list of free nodes to which discussion themes from the interviews can be divided into. The initial nodes list included;

- Contextual data: This included statement on where they have lived in the past and whether they had a bore etc.
- Bore, set-up and use: This relates to the knowledge expressed by the participant about their bore.
- Hydro-geology: This includes any details expressed that relate to water movement through the ground.
- Water cycle: This included details of how the participants see the movement of water through the environment.
- Water Rights: This includes details of any expressions of people's right to use the groundwater, and how much they have the 'right' to use.
- Governance: This includes regulations, restrictions, who should use what or what should be done.

This data was not taken beyond the point of coding as further analysis was not required, the aim of the pilot tests were not to produce results, but to practice all aspects of the data collection and management phases.

Pilot Interview Guide

This guide was developed as below after the first four pilot tests had been undertaken. From this stage it was further refined into the interview guide included within the methods section of this thesis.

Theme 1: Building on Context
Aim: Want to explore previous experiences and general background details of participant and their bore ownership.

Q. *So can you tell me a little about how you came to be living in [suburb]?*

Follow up with questions relating to whether they were in the city or country, perhaps where they grew up, if that seems important (i.e. perhaps they grew up along the Murray river or something and have dealt with water resource issues in the past)... prompts for these may include:

- Where were you living before, or can you describe it to me? Was it in the city or the country?
- ...and what was your lifestyle like there? (for instance, had they grown up on a farm with wide scale irrigation/stock/crops, have they just moved from the country/interstate?... etc.).
- What were your water supplies like there? Did you have a bore? (or some other means of water supply besides a scheme water supply?)
- Did you install the bore yourselves? What were some of your reasons then for installing the bore? (e.g. did they have an orchard or stock to water, did they have a licensed allocation?)

Q. ...*And how about the bore on this property can you tell me a little about that?*

. Follow up prompts may include:

- Do you know when was the bore installed here?
- What were some of your reasons for installing the bore?
- If the bore already installed, may perhaps ask...So how do you find having the bore...would you install another one yourselves if you moved to a property that did not have one? (Remembering also whether they had previously had a bore or not – did they install it themselves both times?)
- And how have you found it in relation to its quality and quantity (do they think their supply is of a good or poor quality, has it ever run dry?...etc)

Theme 2: Perception of Resource: Access, Use and the Groundwater System
Aim: Want to explore how participants perceive the resource and their access and use of it.

Q. *Could you please draw for me a rough diagram of your bore and the water resource, something that could show me where the water comes from and how you use it*

- Ask the participant to add, using notes and further drawings on the diagram, the movement and interaction of the water above and below ground?
- How about downstream from you? what could you tell me about that?
- So what do you think may occur around here resulting from the use of bores? What do you think may be some of the consequences of bore use around here?
- Do you know if any of their neighbours have bores?
- Can you ever tell if one of your neighbours has been pumping from their bore nearby when you go to use your bore?
- Do you feel you have a degree of ownership over the groundwater here/ do you think bore users feel they had a degree of ownership over the groundwater?
- Who should make the decisions about how you use your bore?
- Are you aware of who manages groundwater resources?
- If they mention are they limits? Turn the question around and say "well are there limits/do you know of any limits?"
    - Who should set the limits?
    - Why should there be limits?

Initial Post-piloting nodes:
- Context (past bore ownership/groundwater knowledge/participation)
- Water cycle
- Hydro-geology
- Bore set up and use
- Issues and concerns
- Governance
- Water rights

Greeting and Interview Introduction Scripts

The introduction given when potential participants had been approached generally adhered to the statement below:

> Good morning/afternoon, my name is Beverley and I am a student from Edith Cowan University in Joondalup. I am currently working on a project looking at exploring people's perceptions to domestic groundwater use, you may have received a letter about it in your mail box recently...? (yes/no) Well basically I am out in the area today looking for people who own a bore and have a spare 30 minutes or so to participate in an interview exploring your perceptions to bore and groundwater use, would you be interested...? (yes) That's great, I do have one small favour to ask though and that is would you mind if I recorded the interview?(no). That's great, well let's get to it if you like...

If a participant said they weren't interested or did not have a bore they were thanked for their time. If a participant did not wish to be recorded, or seemed hesitant, it was to be explained that they would remain anonymous on the transcripts and that only myself and project supervisors and advisors would see the transcripts as a whole. Fortunately, those who were interested in participating did not change their minds when asked how they would feel being recorded.

Introduction given prior to undertaking interview:

> First we will start off just discussing a little about how you came to be living here and a little about the bore itself, we will then move on to discussing several aspects relating to groundwater nature and dynamics. During this stage I may get you to draw a diagram of your bore and how it gets to the groundwater. After this we will go onto to discuss topics relating to groundwater use and management.

Consent Form – For voice recording.

Dear Participant,

You have volunteered to participate in an exploratory interview on the subjects of groundwater use in your household and your views and perceptions towards the use and management of groundwater resources around Perth.

To ease the later data transcription process these interviews will be recorded by a digital voice recorder.

Please fill in required sections below

I_____ give permission for Beverley Drayton-Witty to record this interview, taking place on the day as signed below, for the purposes of the research project being undertaken.
I will allow for this information to be used as part of a published thesis.
I am aware that this data will be non-identifiable to me to maintain anonymity.
I am aware that the transcription will not be included in the final thesis, however, it may be viewed by the students' research supervisors.

Signed_____ Date_____

Contact Details for Transcription Confirmation

Dear Participant,

Please enter your contact details below so that the research student can contact you in order to confirm the interview transcript as being true and accurate.

The interview transcript will not be stored with these details to help maintain your anonymity. The information collected from you below will be kept confidential and used only for the purposes of contacting you to confirm the transcript.

Name:_____
Postal Address: _____
Phone: _____

How do you wish to receive the interview transcript?
Email
Email address:_____
Or
Post (address as supplied above) or _____

HUMAN RESEARCH ETHICS COMMITTEE
For all queries, please contact:
Research Ethics Officer
Edith Cowan University
100 Joondalup Drive
JOONDALUP WA 6027
Phone: 6304 2170
Fax: 6304 2661
Email: research.ethics@ecu.edu.au

Dear Householder,

This is a letter just informing you that over the next 2 weeks residents from your neighbourhood may be approached by a research student from Edith Cowan University who will be out door-knocking for participants to volunteer their time for a 30 minute interview to discuss several aspects of domestic groundwater use.

If you are the owner of a groundwater bore (or connected via a shared bore), and are interested in volunteering 30 minutes of your time, please read the following project information and keep an eye out for the research student over the coming weeks.

Project Information Letter

Project Title: ***Public Perceptions towards Groundwater Dynamics, Use and Management.***

As part of the requirements of an Honours Thesis project in Environmental Management at Edith Cowan University, you have been approached as a potential participant for an interview aimed towards exploring the views and perceptions of domestic bore owners in relation to their groundwater use, as well as to groundwater dynamics and management. It does not matter how much or how little you may know about your bore and the groundwater resource as this is not an interview on technical understandings, but rather an exploration about what people think about their bore and the use of groundwater. Your time and input in this project will be greatly appreciated.

This interview is entirely voluntary and participants may withdraw at any time with no further repercussions.

To be considered for an interview you must be;

a) The user of a domestic/garden bore,
b) 18 years +,
c) The homeowner or primary renter of the property fitted with the bore (or shared bore).

The interview will be carried out at your place of residence and will take approximately 30 minutes of your time, and, given your consent, is likely to be audio-taped. All information received from you during this interview will remain anonymous. The interview recording will be reviewed by the research student and transcribed (typed into written form) where the students Project Supervisors

may also then review it. All identifying features (i.e. people/road names etc.) will be omitted from the transcription to further maintain your anonymity.

If you are uncomfortable or unsure of any of these arrangements, or have any questions about the research project, please discuss your concerns with the research student on the contact details supplied at the end of this letter, or in-person at the time of contact.

This project has been approved by the ECU Human Research Ethics Committee.

If you are usually unavailable during office hours and are interested in participating in an interview, it would be greatly appreciated if you could please contact the research student using the contact details below so that an interview time may be arranged to suit you.

Contacts

Beverley Drayton-Witty (research student)
Email: bdrayton@student.ecu.edu.au
Mobile#: 0407 774 889

Associate Professor Pierre Horwitz (Supervisor)
Email: p.horwitz@ecu.edu.au

If you have any concerns or complaints about the research project and wish to talk to an independent person, you may contact:
Research Ethics Officer
Edith Cowan University
100 Joondalup Drive
JOONDALUP WA 6027
Phone: (08) 6304 2170
Email: research.ethics@ecu.edu.au

Thank you very much for your time, I hope to meet with you soon.
Without your input a project like this would not be possible.

Yours Sincerely,
Beverley Drayton-Witty.

Honours Research Student
School of Natural Sciences
Edith Cowan University.
Joondalup, WA.

For all queries, please contact
School of Natural Sciences
Edith Cowan University
270 Joondalup Drive
Joondalup W.A. 6027
Telephone: (61 8) 6304 5189
Facsimile: (61 8) 6304 5509
Email: sons@ecu.edu.au

Dear ,

Accompanying this letter you will find a copy of the transcription from the interview held with you on .

If you wish to clarify or query anything that is written, please do not hesitate to contact me (details below) or return the transcript with any additions/amendments you wish to make to any responses given by you.

I thank you again for the time you spared to assist me in my research project. This project would not have been possible without your help.

Thank you again and kind regards,

Beverley Drayton-Witty
Research Student (Honours)
School of Natural Sciences
Edith Cowan University
Joondalup, W.A.

Contact Details:
Beverley Drayton-Witty (Research Student)
Address:
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If you have any concerns or complaints about the research project and wish to talk to an independent person, you may contact:
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